State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Division of Planning

CENTRAL VALLEY FUTURE WATER SUPPLIES FOR USE IN DWRSIM

Hydrology Development Unit
Modeling Support Branch

September 1995

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Foreword

This report documents key elements used in estimating Central Valley future water supplies tributary to the Delta for use in DWRSIM planning studies: (1) A physical layout of each Depletion Study Area, (2) the procedure and data sources for calculating the historical outflow of each area, and (3) the procedure for calculating the projected outflow of each depletion study area at future levels of development. The report also lists the IN's and YD's used in the current DWRSIM, and the hydrology components that define each.

The entire process of estimating the future water supplies is known collectively as hydrology development using the Depletion Analysis approach. The procedures were developed jointly by the Department of Water Resources and Bureau of Reclamation representatives more than thirty years ago, and have undergone improvements over time.

Hydrology development is a lengthy, data intensive, and complicated procedure. This report should serve as a reference for all parties who have an interest in learning more about what is involved in preparing DWRSIM input data files for use in planning studies.

George W. Barnes, Jr., Chief
Modeling Support Branch

Contents

Contents (Continued)

Figures and Tables

Contents (Continued)

Contents (Continued)

Contents (Continued)

Contents (Continued)

Contents (Continued)

Page

Appendices

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Introduction

This report describes key elements used in the hydrology development process for developing input for the Department of Water Resources reservoir simulation model, DWRSIM. DWRSIM is designed to operate the State Water Project (SWP) and the Central Valley Project (CVP) System reservoirs at a present or future level of development. The SWP is operated by the Department of Water Resources (DWR) and the CVP is operated by the United States Bureau of Reclamation (USBR).

Development of a hydrology consists of three procedures carried out in sequence:

1. Application of the Consumptive Use Model to determine land use based water demands at historic and future levels of development.

2. Application of the Depletion Analysis Model and the COMP Model (a FORTRAN spreadsheet program) to determine the effects of future water demands and future non-project storage and diversion regulation on historic flows.

3. Developing the time series input to DWRSIM (IN's and YD's) by aggregating components from the previous two steps.

These steps are discussed in more detail below:

STEP 1. Consumptive Use Model

The Consumptive Use Program determines historic and future water use in the Sacramento Valley, the San Joaquin River Basin, and the Delta Service Area. The Program allocates precipitation, soil moisture storage, and irrigation water to meet crop and urban evapotranspiration requirements.

Output from the CU Studies becomes input to the depletion studies described in Step 2. The output includes 4 tables:

1. Historic depletion by irrigated and urban areas.
   depletion = consumptive use (CU) of precipitation
   + change in soil moisture storage
   + CU of applied water
   + non-recoverable losses
   (10% of CUAW in valley floor areas and 15% in upstream areas)

2. Native vegetation consumptive use (NVCU) on the same historic irrigated and urban areas (also known as 'historic replaced NVCU').
3. Projected consumptive use of irrigated and urban areas.
4. Projected replaced NVCU.

STEP 2. Depletion Analysis Model

The Depletion Analysis determines the effect of future water demands and future storage and diversion regulation on the historical flows of the river systems tributary to the delta. The depletion analysis method computes the future outflow flow of a depletion area by adjusting the historic outflow for any changes in water use occurring upstream from the outflow point.

The large drainage areas of the Sacramento River, Yolo Bypass, Eastside Streams and San Joaquin River basins are split into smaller drainage and service areas from which water supplies and demands can be more easily evaluated. The individual areas are called depletion study areas or depletion areas. The lowest point where surplus runoff would drain is called the 'outflow point' of the depletion area.

Central Valley has been divided into 37 depletion study areas. A brief description of the Depletion Areas is presented in Table 1. It should be noted that Depletion Areas (DA's) 54 and 55 which are the lowlands and uplands of the Sacramento- San Joaquin Delta are treated as a single Depletion Area (DA 55) in this report. Figure 1 shows a map of the depletion areas.

TABLE 1: DWR DEPLETION STUDY AREA (Page 1of 2)

AREA	DESCRIPTION	UPSTREAM AREAS	BASIN AREA 1000 Acres
	Upper Sacramento River Basin		
61	Pit River above Fall River	none	2337
62	Sacramento River at Shasta Res.	61	1772
3	Paynes Creek Group *	none	65
58	Sacramento River at Red Bluff	62 and 3	1603
5	Thomes and Elder Creeks	none	181
11	Stony Creek below Black Butte Res.	none	472
66	Northeast tributaries: Antelope, Mill, Deer and Big Chico Creek Groups	none	541
10	Sacramento River at Ord Ferry	58, 5, and 66	755
15	Sacramento River at Knights Landing	10	351
12	Sacramento Valley westside above Colusa Basin Drain	none	914
	Total Area Upper Sacramento Basin		**8991**
	Feather River		
17	Feather R. at Oroville	none	2310
14	Butte and Big Chico Creeks	none	150
67	Upper Yuba River including Deer and Dry Creeks	none	842
68	Bear River at Camp Far West Res.	none	187
69	Lower Feather to mouth	17, 14, 67, & 68	910
	Total Area Feather River		**4399**
	Lower Sacramento River Basin		
22	American River at Folsom Res.	none	1191
70	Lower Sacramento River to the Delta	12, 15, 69, & 22	492
	Total Area Lower Sacramento Basin		**1683**
	Cache, Putah, and Yolo Bypass		
16	Cache Creek above Rumsey	none	611
24	Putah Creek near Winters Res.	none	367
65	Yolo Bypass and westside minor streams	16 and 24	592
	Total Area		**1570**
	Delta Eastside Streams		
25	Consumnes above Michigan Bar	none	407
27	Dry Creek at Galt	none	140
29	Mokelumne above Camanche Res.	none	372
32	Calaveras above Jenny Lind	none	252
59	Eastside Streams to the Delta	25, 27, 29, & 32	976
	Total Area Eastside Streams		**2147**

TABLE 1: DWR DEPLETION STUDY AREA (Page 2of 2)

AREA	DESCRIPTION	UPSTREAM AREAS	BASIN AREA 1000 Acres
	Delta Westside Tributaries		
51	Westside minor streams inflow to the south Delta	none	**230**
	San Joaquin River		
39	Stanislaus River at Melones Res.	none	631
40	Tuolumne River above La Grange Dam	none	980
41	Merced River at Exchequer	none	664
42	Bear Creek Group	none	221
43	Chowchilla River above Buchanan Damsite	none	170
44	Berenda Creek	none	32
45	Fresno River	none	228
46	San Joaquin at Friant	none	1072
49	San Joaquin River Vernalis to Friant	39 thru 46	2947
	Total Area San Joaquin River above Vernalis		**6945**
	Delta		
54	Delta Lowlands	55	462
55	Delta Uplands	49, 51, 59, 65,70	216
	Total Delta Area		**678**

Note: Consumptive Use and Depletion Studies were not made for the Tulare Basin, area 60.
* The term 'Group' indicates that in addition to the named creek some unmeasured local runoff has been added.

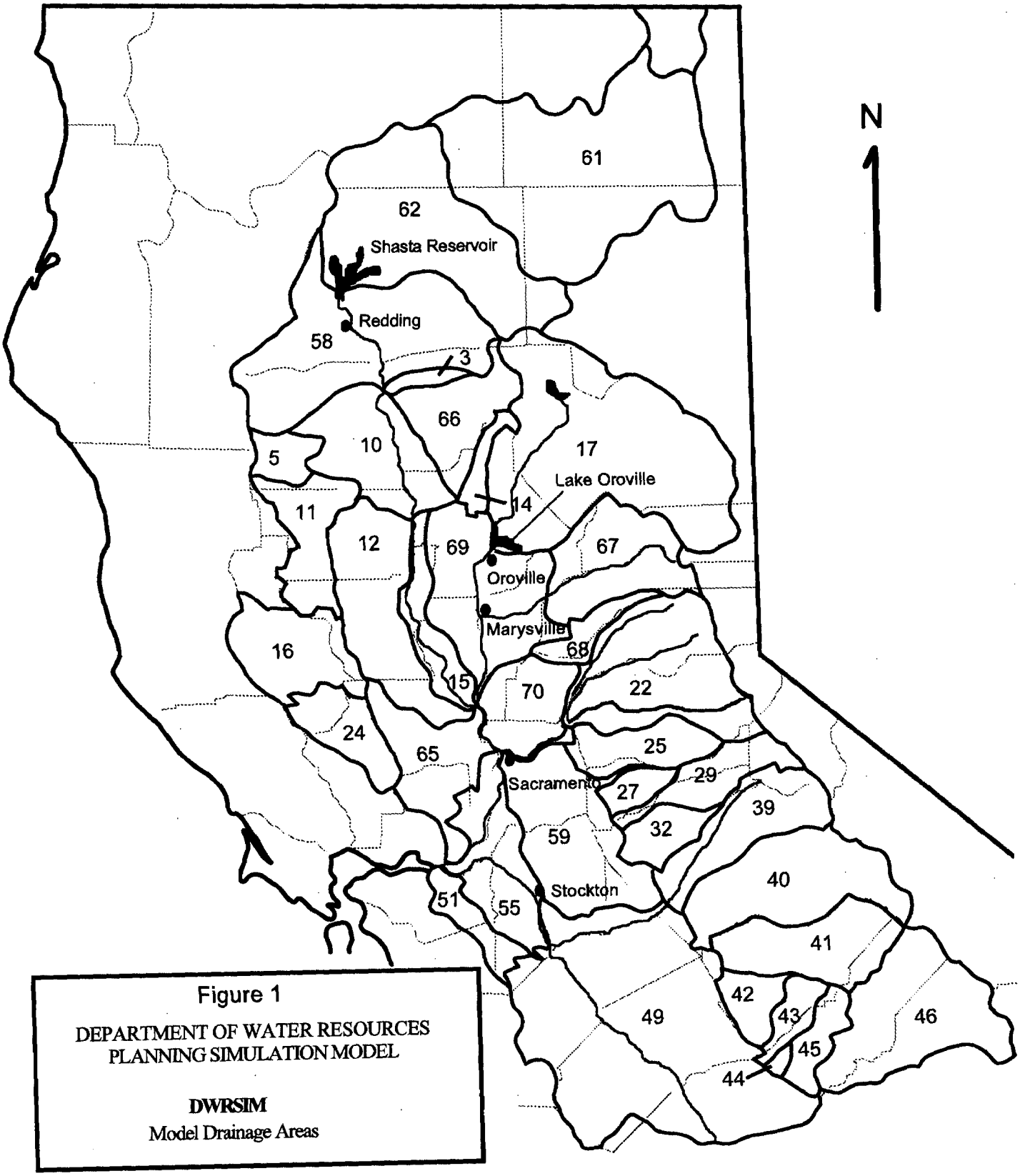


Figure 1

DEPARTMENT OF WATER RESOURCES
PLANNING SIMULATION MODEL

DWRSIM
Model Drainage Areas

STEP 3. Development of IN's and YD's

Local inflows (IN's) and diversions (YD's) are developed from depletion study output using a general purpose mathematical operations program called the "COMP" model.

An 'IN' represents local inflow along the reach of a river. The reach is defined by an outflow point and an inflow point. In general an 'IN' table is computed as the Projected Outflow of a depletion area minus the Projected outflow of the upstream areas plus local diversions and exports minus local return flow.

A 'YD' table represents the local diversion and or export between an outflow point and an inflow point. The diversions are computed in the valley floor depletion areas.

Additional adjustments are made to some of the local inflows and diversions before they are finally converted into IN's and YD's. These include deficiency adjustments on the diversions and removal of project waters from local inflows. Table 2 below lists the formulas used to convert depletion analysis output to IN and YD data for DWRSIM. Figure 2 shows the DWRSIM model network diagram with control point numbers corresponding to the IN and YD formulas.

TABLE 2: LOCAL INFLOW (IN) AND DIVERSION (YD) FORMULAS (Page 1 of 7)

VARIABLE	DERIVATION
IN1	Inflow to Clair Engle Reservoir
IN94	Inflow to Lewiston Reservoir
IN3	Clear Creek Inflow to Whiskeytown Reservoir
IN4	Projected Inflow to Shasta Reservoir
IN6	Projected Inflow to Oroville Reservoir
IN7	Projected Kelly Ridge
YD17	Placer County Water Agency (PCWA) diversion at 25 TAF/yr
IN17	+ 22-80 Auburn Inflow = American HEC3 model river flow at CP11. + 22-80 PCWA Diversion = American HEC3 model diversion at CP11. + 81-92 Auburn Inflow (same as historic)

TABLE 2: LOCAL INFLOW (IN) AND DIVERSION (YD) FORMULAS (Page 2 of 7)

VARIABLE	DERIVATION
IN8	+ 22-80 Folsom Inflow = American HEC3 model river flow at CP57. + 22-80 Folsom Inflow = American HEC3 model river flow at CP58. + 22-80 PCWA Diversion = American HEC3 model diversion at CP11. + 81-92 Folsom Inflow (same as historic) - 22-92 Auburn Inflow
IN9	Folsom to Fair Oaks Accretions (22-80 from American R. HEC model, 81-91 by Correlation DA70 Precipitation)
IN73	Cottonwood Creek (1992 same as 1991)
IN75	+ 22-78 Thomes Creek at Paskenta + 79-92 Thomes Creek at Paskenta
IN76	+ 22-80 Projected Releases Black Butte Reservoir + 81-92 Stony Creek below Black Butte Dam
YD61	+ Historic Outflow DA15 -..Historic flow at the Navigation Control Point (NCP) Historic Flow Sacramento River at the NCP = minimum of Historic Outflow DA15 and Sacramento River at Wilkins Slough Historic Flow Sacramento River at Wilkins Slough = + 22-40 Sacramento River at Colusa + 22-40 Bank Overflow to Butte Basin + 41-92 Sacramento River at Wilkins Slough + 41-92 Bank overflow to Butte Basin + 41-92 Moulton Weir to Butte Basin + 41-92 Colusa Weir to Butte Basin + 41-92 Tisdale Weir Spill to Sutter Bypass
YD3	Clear Creek Water Rights + CC South + Shasta PUD + Clear Creek Fish
YD74	Positives of 50 = + 22-92 Direct Diversions of streamflow DA58 - 24-92 Deficiency Sacramento Water Users and Canals DA58

TABLE 2: LOCAL INFLOW (IN) AND DIVERSION (YD) FORMULAS (Page 3 of 7)

VARIABLE	DERIVATION
YD13	Positives of 53 = + 22-92 Direct Diversion of Streamflow DA10 - 24-92 Deficiency Sacramento Water Users and Canals DA10
YD79	Projected Export DA10
YD77	Positives of 258 = + YD13 Diversion Req. DA10 less deficiencies + Projected Export DA10 + Diversion from Storage DA10 + Diversion to Storage DA10
YD32	Positives of 60 = + Direct Diversion of Streamflow DA15 - 24-92 Deficiency Sacramento Water Users in DA15 (YD32 & YD30)
YD14	Projected Export RD1500 Drain to Sutter Bypass (same as historic)
YD31	Projected Export RD1500 Drain to Sutter Bypass (same as historic)
YD45	Projected Export DA15 Sacramento River West Bank to DA12
YD30	+ YD32 Diversion Req. DA15 less Deficiency + Projected Export RD1500 Drain to Sutter Bypass (same as historic) + Projected Export DA15 Sacramento River West Bank to DA12 - Diversion from Storage DA15 + Diversion to Storage DA15
YD44	Positives of 69 = + Direct Diversion of Streamflow DA70 - 24-92 Deficiency Sacramento Water Users in DA70

TABLE 2: LOCAL INFLOW (IN) AND DIVERSION (YD) FORMULAS (Page 4 of 7)

VARIABLE	DERIVATION
IN74	Positives of 96 = + Total Projected Outflow DA58 - Cottonwood Creek (IN73) - Clear Creek Inflow to Whiskeytown Res. (IN3) - Projected Inflow to Shasta Res. (IN4) - DA58 Clear Creek Limited Project Water + Direct Diversion of Streamflow DA58 - Return Flow to DA58 (Negatives are assumed zero for IN74).
IN77	Positives of 99 = + Projected Outflow DA10 - Projected Outflow DA58 - Thomes Creek (IN75) - Stony Creek below Black Butte Res. (IN76) - PW10 + Export DA10 + Diversion REQ DA10 - RF10 - FROM GW + TO GW + Negative YD77
YD76	+ Negative IN74 + Negative IN77
IN30	Positives of 103 = + Projected Outflow DA15 - Projected Outflow DA10 - PW + Export DA15 to DA12 + Export DA15 to DA69 + DIVERSION Req. DA15 - RF15 - From GW + To GW
YD66	+ IN30 DA15 Local Inflow - Negatives of DA15 Local Inflow

TABLE 2: LOCAL INFLOW (IN) AND DIVERSION (YD) FORMULAS (Page 5 of 7)

VARIABLE	DERIVATION
IN37	Positives of 106 = + Projected Outflow DA69 - Projected Kelly Ridge - Projected Inflow to Oroville Res. - PW DA69 - RD1500 Import + DIVERSION Req. DA69 - Return Flow DA69
YD37	+ Direct Diversion of Streamflow DA69 - Deficiencies FRSA Agriculture + Additional Drought Allowance
YD67	+ FRSA Total Agriculture Less Deficiencies + 1990 Level FRSA M&I + Projected Total FRSA Requirement (Less Deficiencies)
YD42	+ IN37 DA69 Local Inflow - DA69 local Inflow + Projected Total FRSA Requirement (Less Deficiencies)
IN43	Positives of 139 = +Projected Outflow DA70 - Projected Outflow DA69 - Projected Outflow DA15 - Projected Inflow Auburn Reservoir Site - Projected Inflow to Folsom Lake - Folsom to Fair Oaks Accretions +YD44 (Direct Diversion of Streamflow DA70 - Return Flow to DA70 +Projected Export Sacramento River RT Bank Diversion. to DA65 +Projected Export City of West Sacramento to DA65 +Historic Fremont Weir Spills to Yolo Bypass

TABLE 2: LOCAL INFLOW (IN) AND DIVERSION (YD) FORMULAS (Page 6 of 7)

VARIABLE	DERIVATION
YD43	+Positives of DA70 Local Inflow - DA70 Local Inflow +Proj. Export Sac. R. RT Bank Diversion. to DA65 +Proj. Export City of West Sac. to DA65 +Hist. Fremont Weir Spills to Yolo Bypass - Future Fremont Weir Reduction due to Increased Upstream Flood Cont.
IN55	Positives of 142 = +Total Projected Outflow DA65 - Future Fremont Weir Reduction due to Increased Upstream Flood Control
IN98	+ Projected Outflow DA59 + 1995 Level Eastside Streams Misc. Modification, Dry + Deficiency in RF Folsom South Canal + Stockton Treatment Plant
YD98	+ Final Calaveras Group Inflow to the Delta + Stockton Treatment Plant
IN10	Projected Inflow New Melones Reservoir
IN51	Accretions Goodwin to Melones
YD51	+ Proj. Diversion. Oakdale and So. San Joaquin ID's + NEG IN51 (81-92 same as historic)
IN80	Stanislaus Accretions Goodwin Dam to Mouth
YD80	Projected Lower Stanislaus Diversions + NEG IN80
IN89	Negatives of 196 = + Kings R. Overflow into Fresno Sl. (Existing Pine Flat Res.) + Millerton Spills limited to 1500 CFS
IN82	Positives of 213 = + Projected Outflow DA49 + Projected Outflow DA51 - Deficiency in Delta Mendota Canal (DMC) Return Flow + 1995 Misc Modification SJR - Proj. Stanislaus Flow at Mouth - DMC Local Supply Adjustment to IN82

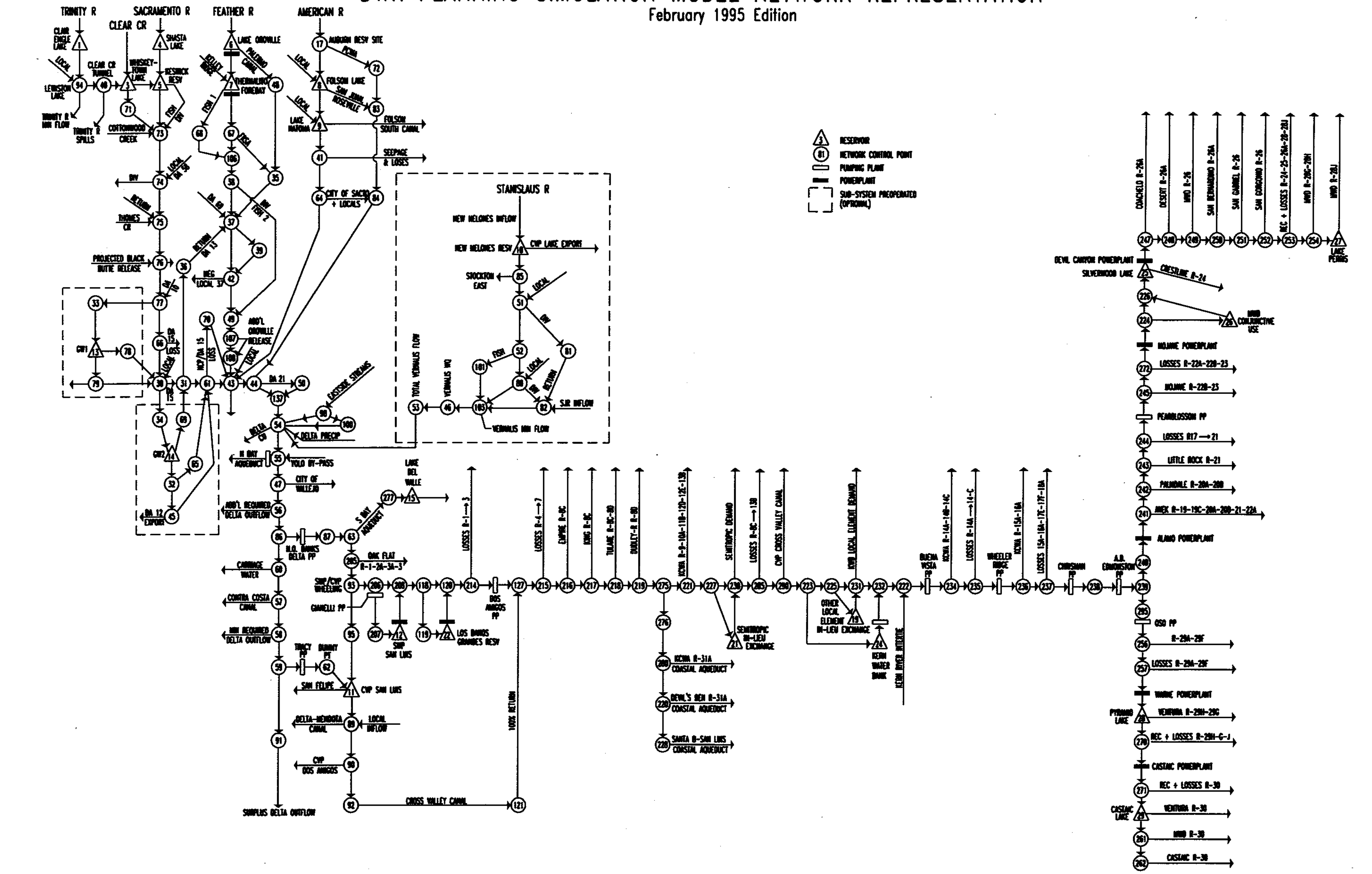
TABLE 2: LOCAL INFLOW (IN) AND DIVERSION (YD) FORMULAS (Page 7 of 7)

VARIABLE	DERIVATION
YD89	+ DMC Exchange Contract Less Deficiency + DMC Schedule. II, Losses, Less Deficiency + DMC Grasslands Less Deficiency + DMC Agriculture and State(19 TAF) Less Deficiency
YD54	Positives of 224 = + Total 1995 Level Consumptive Use Delta Lowlands + Total 1995 Level Consumptive Use Delta Uplands + Delta Lowlands Leach Water Adjustment
IN54	+ Total Basin Precipitation DA54 + Total Basin Precipitation. DA55, Delta Uplands

Figure 2

DWR PLANNING SIMULATION MODEL NETWORK REPRESENTATION

February 1995 Edition



DEPLETION AREA 3
PAYNES AND SEVEN MILE CREEKS

Depletion Area 3 is the drainage area for Paynes Creek and some minor local creeks. Paynes Creek joins the Sacramento River on the east bank between the Red Bluff diversion dam (for Tehama-Colusa Canal) and Bend Bridge (where the Sacramento River at Red Bluff gage has been relocated). See Figure 3, below.

DA3 is of little significant to the DWRSIM hydrology and could probably be merged with DA58 with little consequence.

PROJECTED OUTFLOW: The projected outflow of DA 3 is the same as the historic flow.

HISTORIC OUTFLOW: The historic outflow of Depletion Area 3 was estimated by multiplying the monthly flows of Paynes Creek near Red Bluff by a factor of 1.12 to account for the area runoff not measured at the gaging station. Paynes Creek flows prior to October 1949 were taken from the files of the Sacramento Valley East Side Investigation. Flows for the period October 1950 through September 1966 were taken from United States Geological Survey (USGS) Water Resources Data reports. Paynes Creek flows for the period October 1966 through September 1992 were estimated by annual correlation with USGS station Mill Creek near Los Molinos and Deer Creek near Vina. Annual values were distributed on the monthly pattern of the Red Bluff precipitation station.

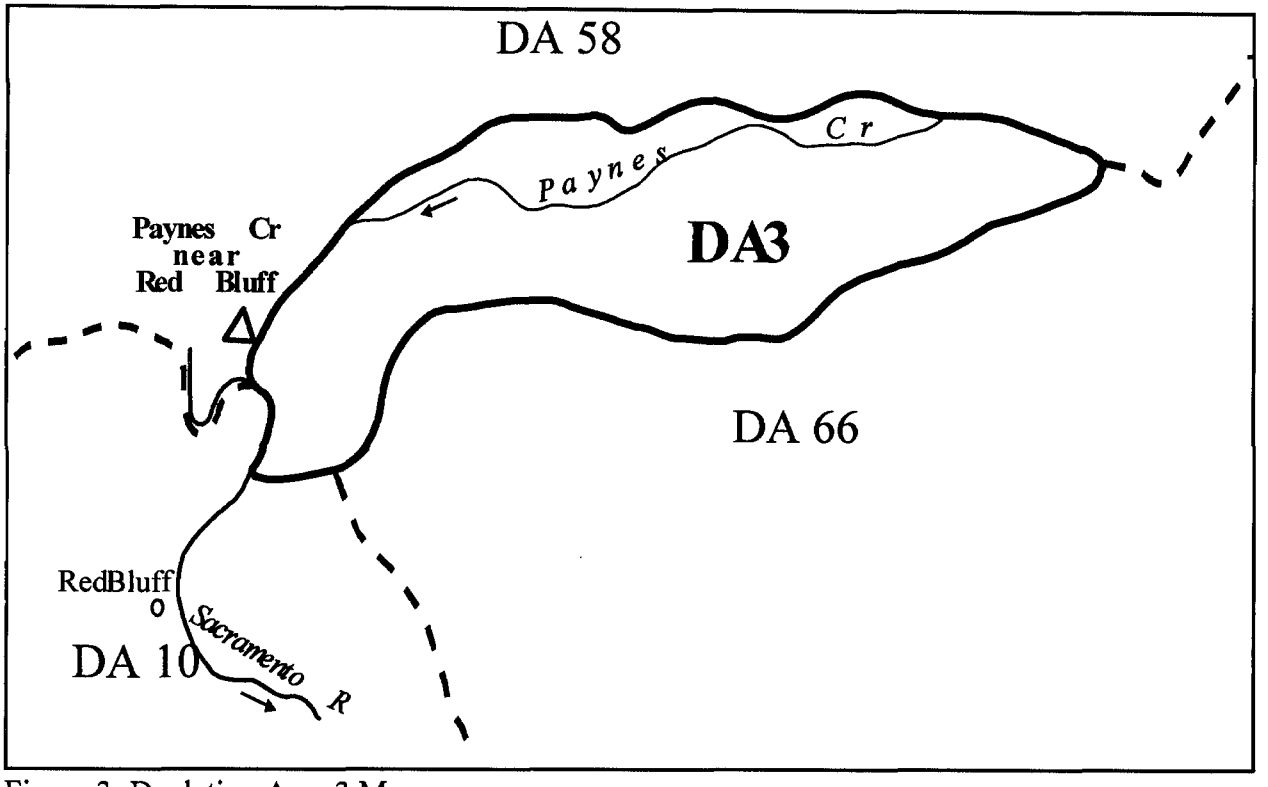


Figure 3: Depletion Area 3 Map

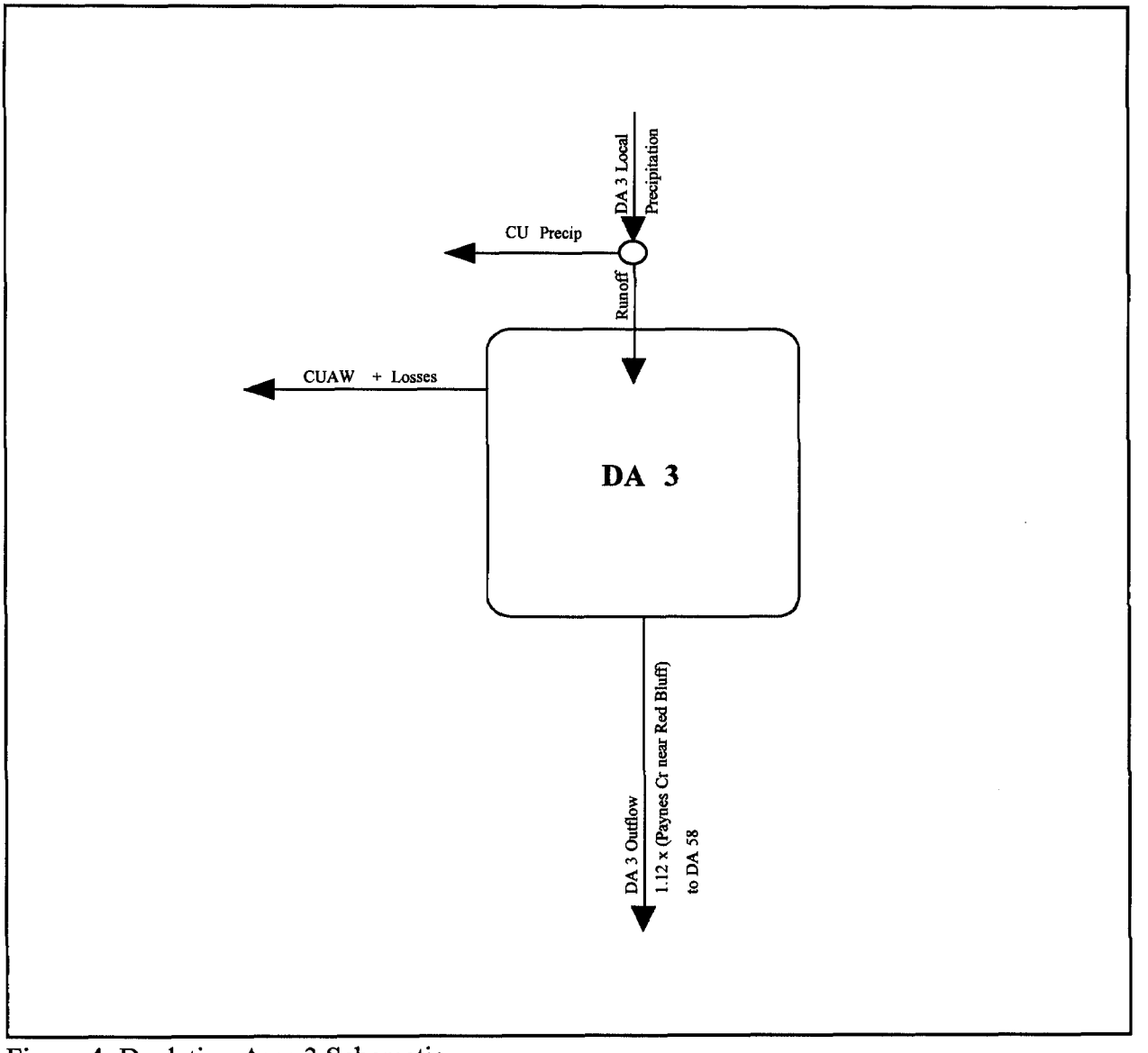


Figure 4: Depletion Area 3 Schematic

DEPLETION AREA 5
THOMES AND ELDER CREEKS

Depletion Area 5 is the drainage area for Thomes and Elder Creeks. It is located on the west side of the DA10. The area has essentially no irrigated land use and is of little significance to the development of DWRSIM hydrology. The area could probably be merged with DA10 with little consequence. The Thomes Creek flows are identified in the DWRSIM as IN75. A map of DA5 is presented below in Figure 5.

PROJECTED OUTFLOW: The projected outflow of DA 5 is the same as the historic flow.

HISTORIC OUTFLOW: The historic outflow of Depletion Area 5 equals the combined flows of Elder Creek near Paskenta and Thomes Creek at Paskenta. The flows for both stations were obtained from USGS Water Resources Data reports. The data covers the period 1922 thru 1991. Water Year 1992 is estimated to be the same as historic.

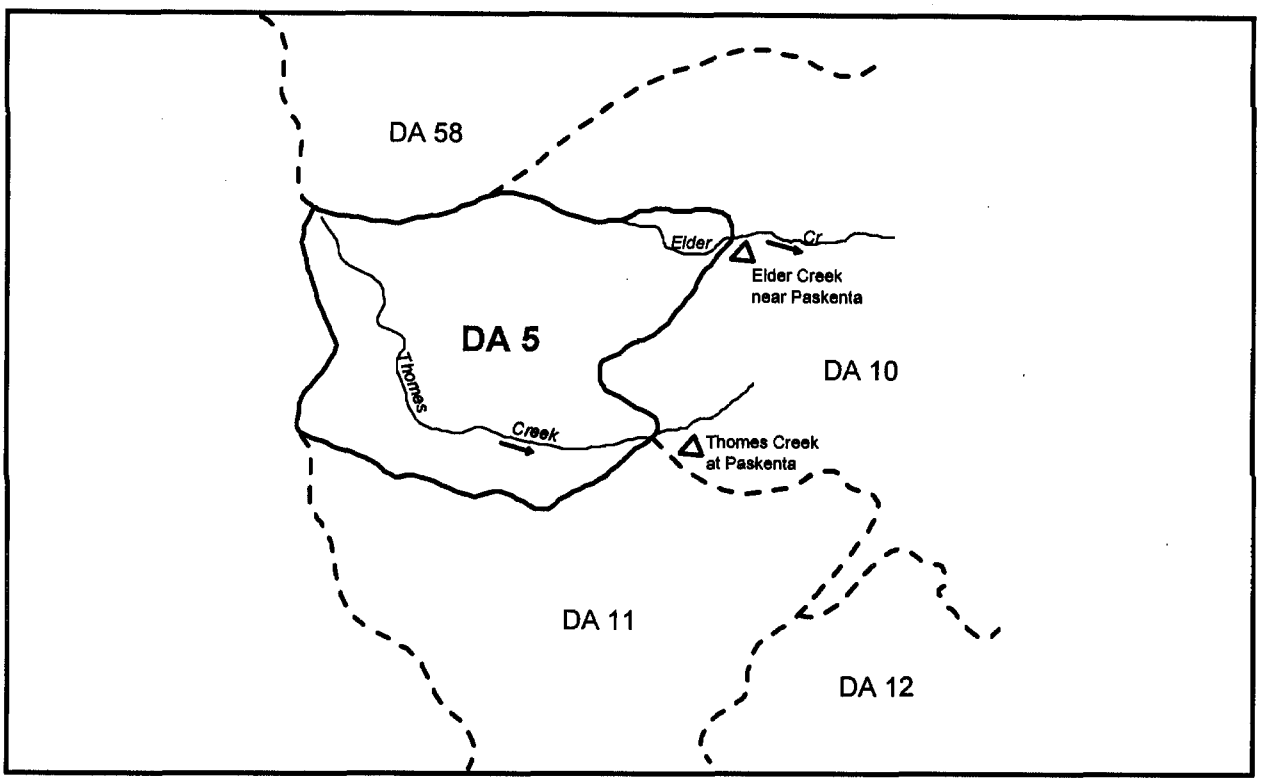


Figure 5: Depletion Area 5 Map

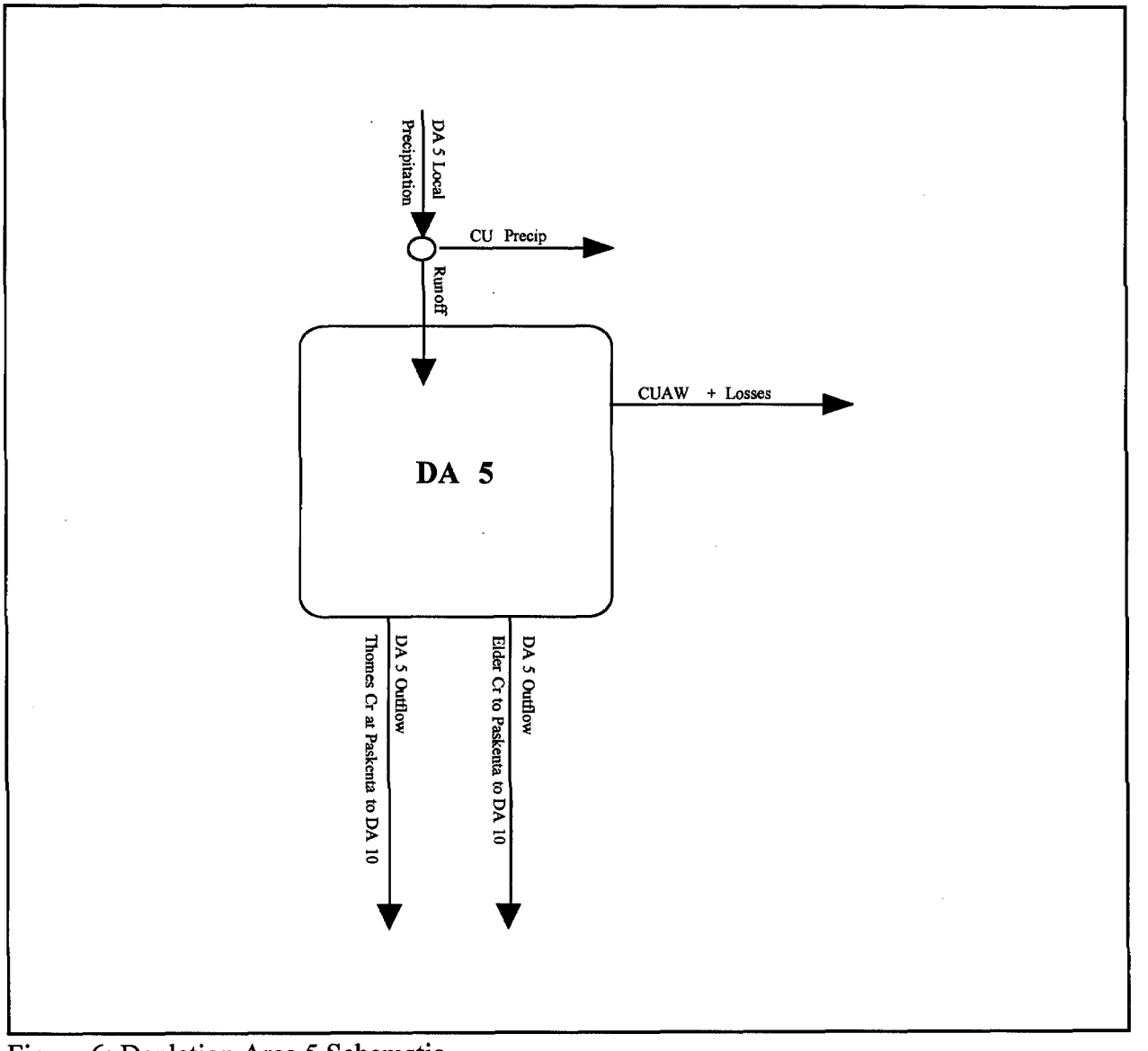


Figure 6: Depletion Area 5 Schematic

DEPLETION AREA 10
SACRAMENTO RIVER AT ORD FERRY

Depletion Area 10 covers the Sacramento Valley floor segment of the Sacramento River between the Ord Ferry gage and the old Red Bluff gage just above the Red Bluff diversion dam. The Ord Ferry gage is located just west of the town of Chico about 8 miles downstream from where Stony Creek joins the Sacramento River.

Upstream areas to DA10 are DA's 5 and 11 on the west side, DA 66 on the east side, and DA58 to the north.

No reservoirs are modeled in DA10.

Several diversions along the Sacramento River serve irrigation districts in DA10. Only two are modeled in DA10 because they deliver water to DA12. They are the Tehama-Colusa and Glenn-Colusa Canals.

The Tehama-Colusa Canal diverts from the Red Bluff Diversion Dam. The diversion dam also diverts water for Corning Canal and for the Tehama-Colusa Fish Facilities (Fish Facilities). Most of the water for the Fish Facilities is returned to the Sacramento River via Coyote Creek. According to Tom Kelly, USBR Willows office, some Fish Facilities water is sent south and ends up in DA12. In the depletion analysis it is assumed that all fish facilities water remains in DA10. The Fish Facilities began operating in the fall of 1971. Available information indicates that deliveries for irrigation began in 1976. For depletion analysis development, only Tehama-Colusa deliveries to areas in DA12 are modeled. These are called Tehama-Colusa Canal exports to DA12.

The Glenn-Colusa Canal diverts from the Sacramento River about 17 miles upstream from the confluence of Stony Creek and the Sacramento River. The canal travels south across Stony Creek where it picks up additional water from Stony Creek. The combined diversions from the Sacramento River and Stony Creek are called exports to DA12.

PROJECTED OUTFLOW is calculated as:

+ Historic Outflow Sacramento River at Ord Ferry
+ Historic Outflow Sacramento. River bank overflows to Butte Basin
+ Historic Export Glenn-Colusa ID Canal to DA12
- Projected Export Glenn-Colusa ID Canal to DA12
+ Historic Export Tehama-Colusa Canal to DA12

- Projected Export Tehama-Colusa Canal to DA12
+ Projected Outflow DA11 Stony Creek below Black Butte Res.
- Historic Outflow DA11 Stony Creek below Black Butte Res.
+ Projected Outflow DA58 Sacramento River at Red Bluff
- Historic Outflow DA58 Sacramento River at Red Bluff
+ Historic Depletion, DA10
- Historic Replaced Native Veg. CU, DA10
- Projected Depletion, DA10
+ Projected Replaced Native Veg. CU, DA10
+ Additional Ground Water Pumping, DA10
- Additional Ground Water Recharge, DA10
+ Project Water DA10

HISTORIC OUTFLOW: The historic outflow of Depletion Area 10 equals the historic flow of the Sacramento River at Ord Ferry plus the historic overflow of the Sacramento River above Butte City. For the period October 1921 - December 1947:

HQ10 = + Sacramento River at Butte City
+ Bank Overflows to Butte Basin
- Sacramento. River diversions, Ord Ferry to Butte City

The combined flows for Sacramento River at Butte City and bank overflows are listed in Table of the 1957 Joint Hydrology Study (1957JHS). The diversions from Butte City to Ord Ferry were compiled from DWR Water Supervision reports. For the period January 1948 to present:

HQ10 = + Sacramento River at Ord Ferry
+ Bank Overflows to Butte Basin

Sacramento River at Ord Ferry flows are from DWR Water Supervision Reports. Flows for the period October 1975 - September 1991 are obtained from DWR Northern District Office. October 1991-June 1992 flows are from the USBR Report of Operations Streamflow Data.

Ord Ferry flows for February 1986 are partial. Missing daily flows are estimated by interpolation.

Flow for August - September 1987 is estimated by linear correlation of computed to actual flow at Ord Ferry. Estimated August - September flow is calculated as:

FLOW = .987(computed flow) - 9

Where:

Computed flow =

+ the Sacramento River at Red Bluff
+ historic flow DA66
- Glenn-Colusa Diversion
- Tehama-Colusa Diversion
+Tehama Fish Return.

Ord Ferry flows for July - September 1992 are estimated using USBR June 1992 forecasted operations flows.

Bank overflow of 18TAF in December 1951 are taken from Table 42 of the 1957JHS. Beginning October 1954 overflows are estimated by graphical correlation with the daily discharge of the Sacramento River at the latitude of Chico Landing. The graph is presented as Plate 21 of 1957JHS. The graph was prepared by the U.S. Army Corps of Engineers. Daily flows for the Sacramento River at Ord Ferry are used in lieu of the Sacramento River at latitude of Chico Landing. No bank overflow occurs when the Ord Ferry daily flow is less than 92,000 cfs.

Bank overflows for the period October 1986 thru September 1992 are assumed to be zero.

HISTORIC EXPORT: DA10 historic export equals the sum of Glenn-Colusa Irrigation District (GCID) and Tehama-Colusa Canals to DA12.

Glenn-Colusa Canal equals the combined diversions from the Sacramento River and Stony Creek.

WY 1922-23 GCID export is estimated to be the same as 1925.

WY 1924-69 was computed by USBR. Diversion from the Sacramento River was taken from DWR Water Supervision Reports, 'Sacramento River diversion at mile 154.8'. Diversion from Stony Creek during the irrigation season were estimated to be equal to the flows of Stony Creek near Hamilton City.

WY 1970-90 are obtained from Penvane meter readings at a point below where GCID Canal crosses Stony Creek. The meter readings include both Sacramento River and Stony Creek diversions. Data for the 1970-80 Beginning November 1970, the historic export was obtained from USBR Monthly Reports of Operations. Beginning January 1977 the historic export was taken from the USBR Monthly Reports of Operations table entitled "Sacramento River Monthly Deliveries".

Tehama-Colusa Canal began diverting in October 1971. From October 1971 to February 1976 its only deliveries were to the Tehama-Colusa fish facilities. The fish facility returns water to the river within the bounds of DA10 and is not considered an export. First agricultural deliveries were made in March 1976. Part of Tehama-Colusa Canal water remains in Depletion Area 10 and part is exported to Depletion Area 12. Tehama-Colusa Canal users located in DA10 and DA12 are:

DA10	DA12
Elder Creek WD	Baker
Kirkwood WD	Colusa Co.
O'Connel Mutual WU	Colusa Co. WD
Orland WU	Cortina WD
Ranch Saucos WD	Davis WD
Richfield	Dunnigan WD
Tehama Ranch MWC	Dutro
Tehama WD	4-M WD
Stony Creek Ground Water Recharge	Glenn Valley WD
	Glide WD
	Holthouse WD
	Kanawha WD
	LaGrand WD
	Long Hollow
	Myers-Marsh WD
	Orland-Artois
	Westside WD

Tehama-Colusa Canal deliveries are obtained from USBR Monthly Reports of Operations.

PROJECTED EXPORT: DA10 projected export represents the future Glenn-Colusa and Tehama-Colusa deliveries to DA12. Normal Tehama-Colusa Canal to DA12 is 236 TAF/yr broken down into 172 TAF Full Payment Project Water agriculture base + additional of 64 TAF. Normal Glenn-Colusa export to DA12 is 825 TAF/yr broken down as Sacramento Water Users base supply 720 + project supply of 105 TAF.

25% deficiency was taken in 1924, 1931-34. 50% deficiency was taken in 1977.

These values were updated by J. Maglinte of USBR, 5/28/89.

UPSTREAM AREA MODIFICATIONS:

DA58: Sacramento River above Red Bluff diversion dam. Includes modification to remove

historic Trinity Imports, Whiskeytown Reservoir, and Shasta Reservoir (DA62)

DA11: Stony Creek, including East Park, Stony Gorge, and Black Butte Reservoirs.

DA5: Thomes and Elder Creeks. Upstream area modification for this area equals zero.

BASIN MODIFICATION: Formerly, Depletion Area 10 included a modification for the operation of Black Butte Reservoir when the DA10/11 boundary was located above Black Butte Reservoir. In this depletion study, the boundary has been relocated to Stony Creek below Black Butte Reservoir and the effects of Black Butte Reservoir are now part of DA11.

PROJECT WATER: Project water in DA10 represents required storage withdrawals from the CVP reservoirs: Clair Engle, Shasta, and Whiskeytown to meet local demands. To calculate DA10 project water, a depletion study for DA10 was run without project water to evaluate shortages. Project water equals the shortages limited to maximum project water scheduled by USBR. Maximum project water for DA's 58, 10, 12, and 15 is 586 TAF/yr reduced for deficiencies in 1924, 1931-34, and 1977.

The following table is a breakdown of the maximum project water in 1000's acre-feet/year:

DA58	M & I Redding	5.2
	M & I Shasta Lake	3.0
	Agr. Clear Creek South	10.0
	Agr. Cow Creek	17.3
	Sac. River Water Users	11.8
		47.3
DA10	Corning Canal	
49.0		
	Tehama-Colusa Canal	236.0
	Glenn-Colusa Canal	105.0
	Sac. River Water Users	1.0
		391.0
DA15	Feather WD	20.0
	Sac. River to DA12	26.0
	Sac. River Water Users	102.0
		148.0
	Total	**586.0**

GROUND WATER PUMPING AND RECHARGE: The limited project water and reduced Sacramento River inflow is unable to meet all shortages. Remaining shortages are computed by the depletion analysis program as additional ground water pumping and recharge.

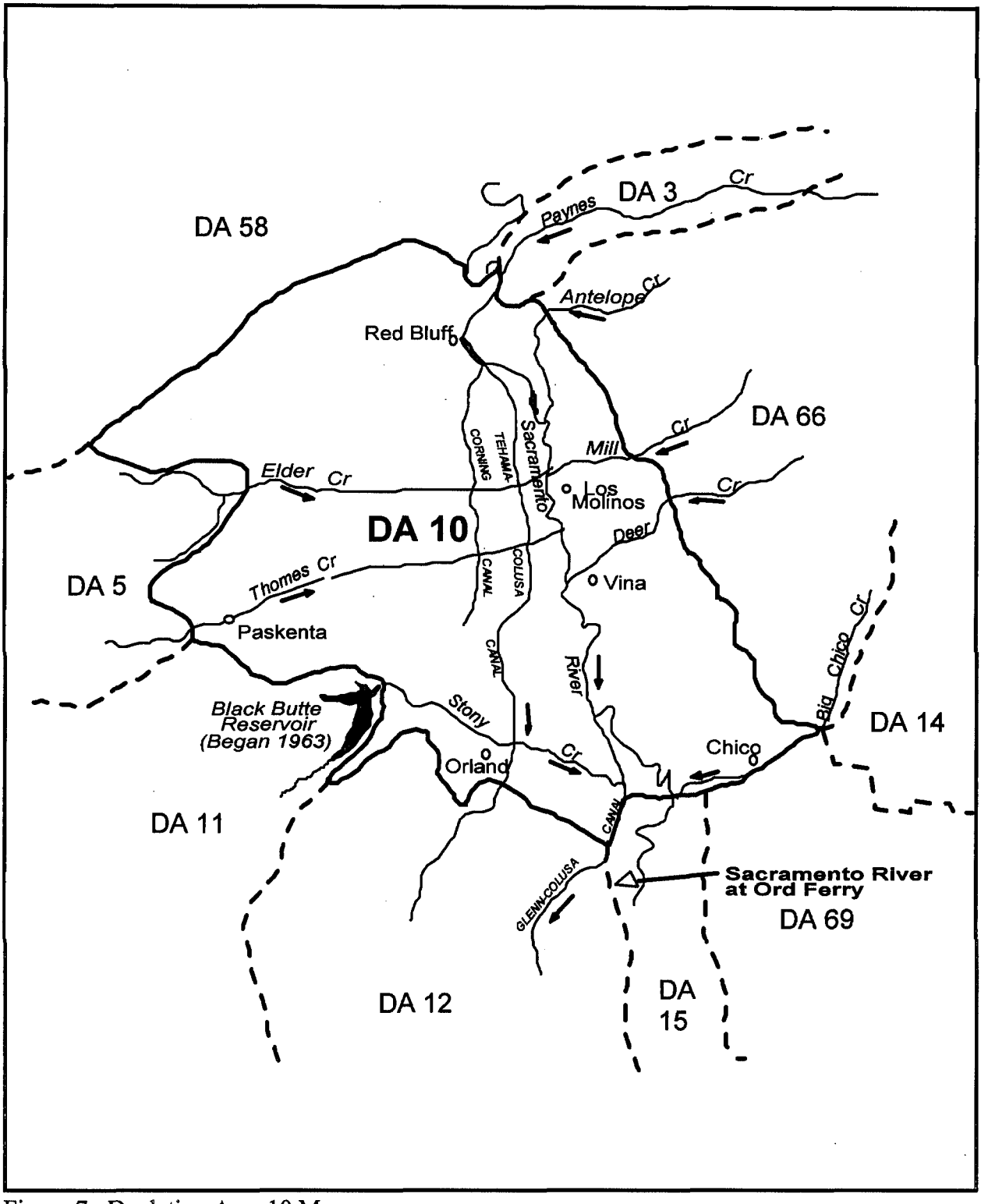


Figure 7: Depletion Area 10 Map

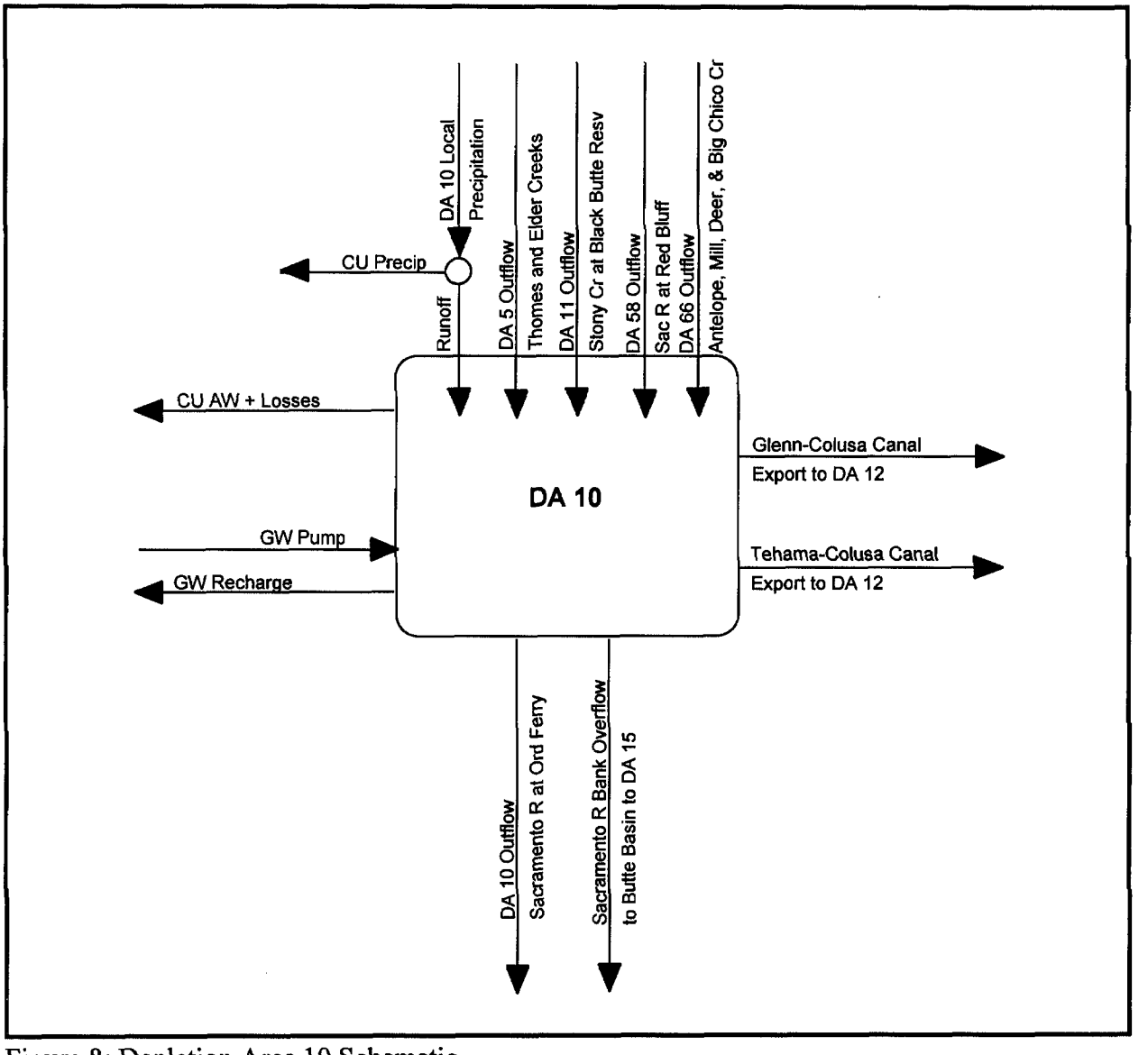


Figure 8: Depletion Area 10 Schematic

DEPLETION AREA 11
STONY CREEK BELOW BLACK BUTTE RESERVOIR

Depletion Area 11 is the drainage area for Stony Creek above Black Butte Reservoir. DA11 is located on the west side of Sacramento Valley and is upstream to depletion area 10.

Three reservoirs modeled in DA11 are Black Butte, Stony Gorge, and East Park.

Reservoir	Year of Completion	Reservoir Capacity (acre-feet)
East Park	1910	50,900
Stony Gorge	1928	50,055
Black Butte	1963	370,000

PROJECTED OUTFLOW: Projected outflow is calculated as:

+ Historic Outflow
+ Historic Depletion
- Historic Replaced Native Veg. CU
- Projected Depletion
+ Projected Replaced Native Veg. CU
+ Historic Change in Storage and Evaporation for East Park, Stony Gorge, and Black Butte Reservoirs
- Projected Change in Storage and Evaporation for East Park, Stony Gorge, and Black Butte Reservoirs

HISTORIC OUTFLOW: Historic outflow of DA11 was taken from DWR Northern District Stony Creek Hydrology report, April 1982.

10/21 - 9/34 Historic outflow equals Stony Creek near Orland + 1.46*North Fork Stony Cr.

10/34 - 12/40 Historic outflow was estimated by correlation with the flow at Stony Gorge reservoir.

1/41 - 12/52 Historic outflow equals the estimated Stony Creek at Black Butte Dam site.

1/53 - 9/91 Historic outflow equals Stony Creek at Black Butte Dam site including South

Diversion Canal. The flows were taken from USGS Water Resources Data reports.

BASIN MODIFICATION: The basin modification is calculated as the projected minus historic effects of East Park, Stony Gorge and Black Butte Reservoir.

Modification to remove the historic effects is equal to the change in storage plus evaporation from the three reservoirs. Change in storage and evaporation for Black Butte and inflow and releases for East Park and Stony Gorge are obtained from USGS Water Resources Data Reports.

The projected modification is based on data from an operation study, developed by DWR Northern District April 1982 was used. The report is called Stony Creek Basin R2 Operation Study, Revision No. 1, DWR Northern District, 4/82. The projected modification is equal to minus evaporation and change in storage of the three reservoirs.

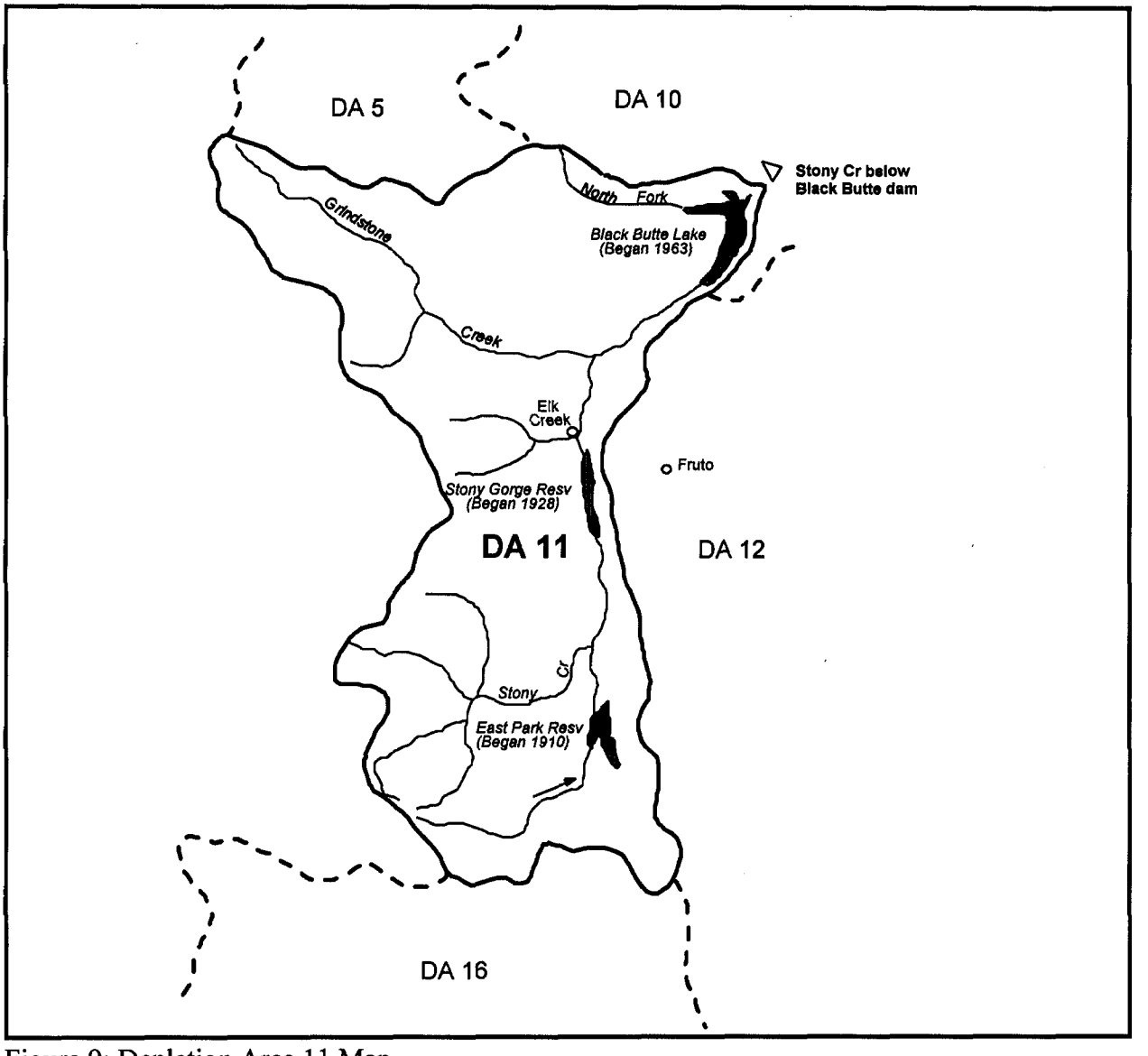


Figure 9: Depletion Area 11 Map

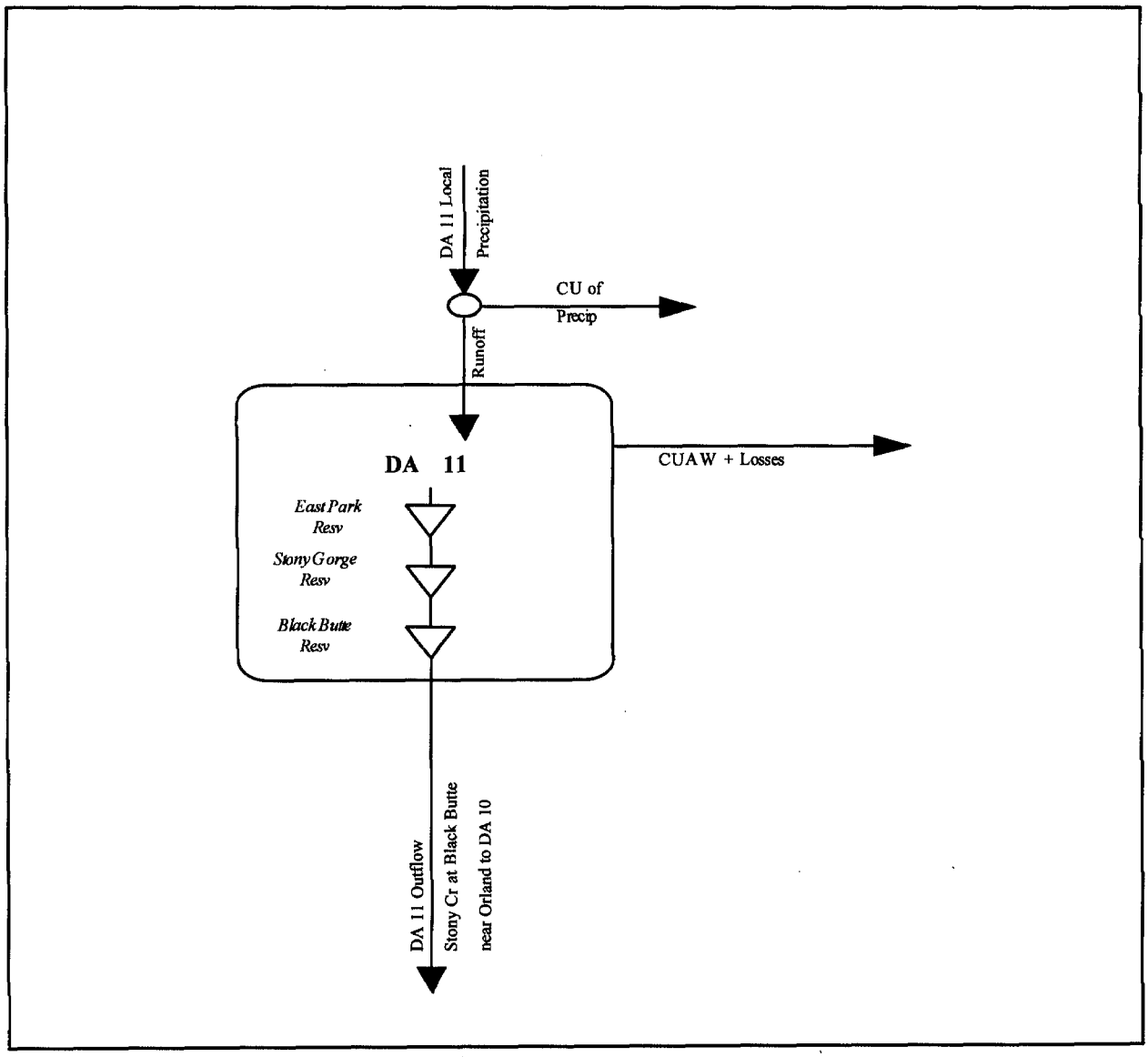


Figure 10: Depletion Area 11 Schematic

DEPLETION AREA 12
SACRAMENTO VALLEY WESTSIDE ABOVE COLUSA BASIN DRAIN

Depletion Area 12 represents the drainage area on the west side of Sacramento Valley Floor between Knights Landing Ridge Cut to the south, and Stony Creek to the north. Surplus water from precipitation and irrigation return flows flow to the Colusa Basin Drain. The surplus water then re-diverted for irrigation and the final water leaves DA12 either through Colusa Basin Drain to the Sacramento River or Knights Landing Ridge Cut to the Yolo Bypass.

There is very little precipitation in the summer months in this area. The irrigated land use must receive its water through groundwater pumping or from import through Tehama-Colusa Canal, Glenn-Colusa Canal, and DA15's west bank diversions.

There are no upstream areas to DA12.

Colusa Basin Drain to the Sacramento River is DA12's outflow point.

Knights Landing Ridge Cut is considered to be an export from DA12 to DA65. Tehama-Colusa Canal and Glenn-Colusa Canal are imports from DA10.

PROJECTED OUTFLOW:

Projected Outflow of DA12 is calculated as:

+ Historic Outflow
+ Historic Export Knights Landing Ridge Cut
- Projected Export Knights Landing Ridge Cut
+ Increased Import Tehama-Colusa Canal from DA10
+ Increased Import Glenn-Colusa Canal from DA10
+ Increased Import Sacramento River from DA15
+ Historic Depletion
- Projected Depletion
+ Projected Additional Ground Water Pumping
- Projected Additional Ground Water Recharge

HISTORIC OUTFLOW: The historic outflow of Depletion Area 12 is calcualted as the flow of the Colusa Basin Drain to the Sacramento River at Knights Landing plus the flow of Sycamore Slough (RD 787) to Colusa Basin Drain.

10/21 - 9/54 Monthly flows were taken from Table 37 of the 1957 Joint Hydrology Study

report.

10/54 - 9/76 Monthly flows were taken from DWR Water Supervision reports.

10/76 - 9/91 Monthly flows were obtained from the DWR Northern District Office.

STATUS: No data for 1986~1988 for Reclamation District 787 drainage to Colusa Basin Drain.

02/87 - 9/87 Flow Colusa Basin Drain to the Sacramento River at Knights Landing was not recorded due to construction on outfall gates.

Data for June, August and September 1989 and December 1990 are estimated using estimated daily flows. October 1991 through May 1992 are estimated, and June - September 1992 is the same as June - September 1991.

HISTORIC EXPORT: The historic export is the Colusa Basin Drain flow to the Knights Landing Ridge Cut in DA65.

10/21 - 12/39. The historic export for some of the winter months was taken from Table 41 of the 1957 Joint Hydrology Study report. The data in Table 41 was obtained from DWR Flood Flow and Stage Reports. Some of the flows were in acre-feet and others were estimated from gage height readings. Summer month flows prior to 1934 were estimated using the following schedule:

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	5	5	3	3	3	2

1/40 - 4/40. KLRC export is not measured directly. A w ater balance method is used to estimate the historic export as follows:

+ Yolo Bypass near Woodland (USGS Water Resources Data reports)
- Fremont Weir spills to Yolo Bypass (DWR Water Supervision reports)
- Cache Creek at Yolo (USGS Water Resources Data reports)

5/40 Historic export for May, 1940 was estimated from partial daily flow data.

6/40 - 12/43. Historic export was taken from DWR Water Supervision Reports.

1/44 - 12/45. Historic export was estimated as:

+ Yolo Bypass near Woodland (USGS Water Resources Data reports)
+ Diversions from Knights Landing Ridge Cut (DWR Water Supervision reports)
- Fremont Weir spills to Yolo Bypass (USGS Water Resources Data reports)
- Cache Creek at Yolo (USGS Water Resources Data reports)

1/46 - 12/55. The historic export was taken from DWR Water Supervision reports.

1/56 - 9/69. The historic export was estimated as:

+ Yolo Bypass near Woodland (USGS Water Resources Data reports)
+ Diversions from Knights Landing Ridge Cut (DWR Water Supervision reports)
- Fremont Weir spills to Yolo Bypass (USGS Water Resources Data reports)
- Cache Creek at Yolo (USGS Water Resources Data reports)

10/69 - 9/91 The historic export was estimated as:

+ Yolo Bypass near Woodland (USGS Water Resources Data reports)
+ Diversions from Knights Landing Ridge Cut (Estimated)
- Fremont Weir spills to Yolo Bypass (USGS Water Resources Data reports)
- Cache Creek at Yolo (USGS Water Resources Data reports)

Knights Landing Ridge Cut diversions were estimated by similar year method using precipitation at Dan Best Ranch as an indication of similar year. During high flow months, this procedure gave erratic results, probably because of difficulty in accurately measuring the large volume of flows occurring in the Yolo Bypass. Knights Landing Ridge Cut flows for December through March and sometimes April were estimated as the total Colusa Basin Drain (CBD) flow less the CBD flow to the Sacramento River. Total flows of the CBD were estimated by correlation with flow at the CBD at Highway 20. Monthly equations are:

December	$Y = 0.86X + 4$
January	$Y = 1.27X + 10$
February	$Y = 1.35X + 1$
March	$Y = 1.16X$
April	$Y = 1.00X$

Y = Estimated Total flow of the CBD
X = CBD flow at Highway 20

CBD at Highway 20 flows were taken from DWR Water Supervision reports until October 1975

when they were obtained from the DWR Central District Office.

PROJECTED EXPORT: Projected exports are calculated as the historic export reduced for additional ground water recharge.

PROJECTED AND HISTORIC IMPORTS: Imports into DA12 come from the Tehama-Colusa and Glenn-Colusa canals in DA10 and the Sacramento River right bank diversions in DA15. Projected and historic imports are described in further detail under DA's 10 and 15 exports.

PROJECTED DEPLETION: It is customary to compute the additional runoff in the depletion analysis model. The additional runoff, however, becomes unavailable as a supply for ground water recharge.

In DA12 the additional runoff was assumed to be available as a recharge supply. To accomplish this, the additional runoff was computed outside the depletion study and input as a modification.

The additional runoff was computed by first subtracting the projected replaced native vegetation consumptive use from the consumptive use of irrigated and urban. The results consist of negatives in the winter months and positives in the summer. The absolute value of the negatives are considered additional runoff. The positives are considered consumptive use of applied water.

To avoid double-counting the additional runoff, the consumptive use of applied water becomes input to the depletion study in place of the projected CU of irrigated and urban lands and the projected replaced native vegetation CU tables.

The diversion requirement equals the projected CU of applied water divided by DA12 efficiency factors. The monthly efficiency factors for DA12 were revised from previous studies. They are as follows:

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Normal Year	.30	.70	.70	.70	.70	.70	.79	.70	.84	.81	.67	.41
Critical Year	.79	.70	.70	.70	.70	.70	.90	.70	.89	.89	.77	.60

The revised efficiency factors were determined from the historic consumptive use of applied water (cuaw) and historic DA12 return flow. The return flow is identified from DA12's historic outflow and export.

The equation for computing the efficiency factor is:

$$e = cuaw / (1.1*cuaw + return\ flow)$$

Normal year efficiency factors are averaged for the period 1971-76 and 1979-80. The critical year efficiency factors are the same as 1977.

GROUND WATER PUMPING AND RECHARGE: Ground water pumping and recharge are based on a simulation model developed by Boyle Engineering.

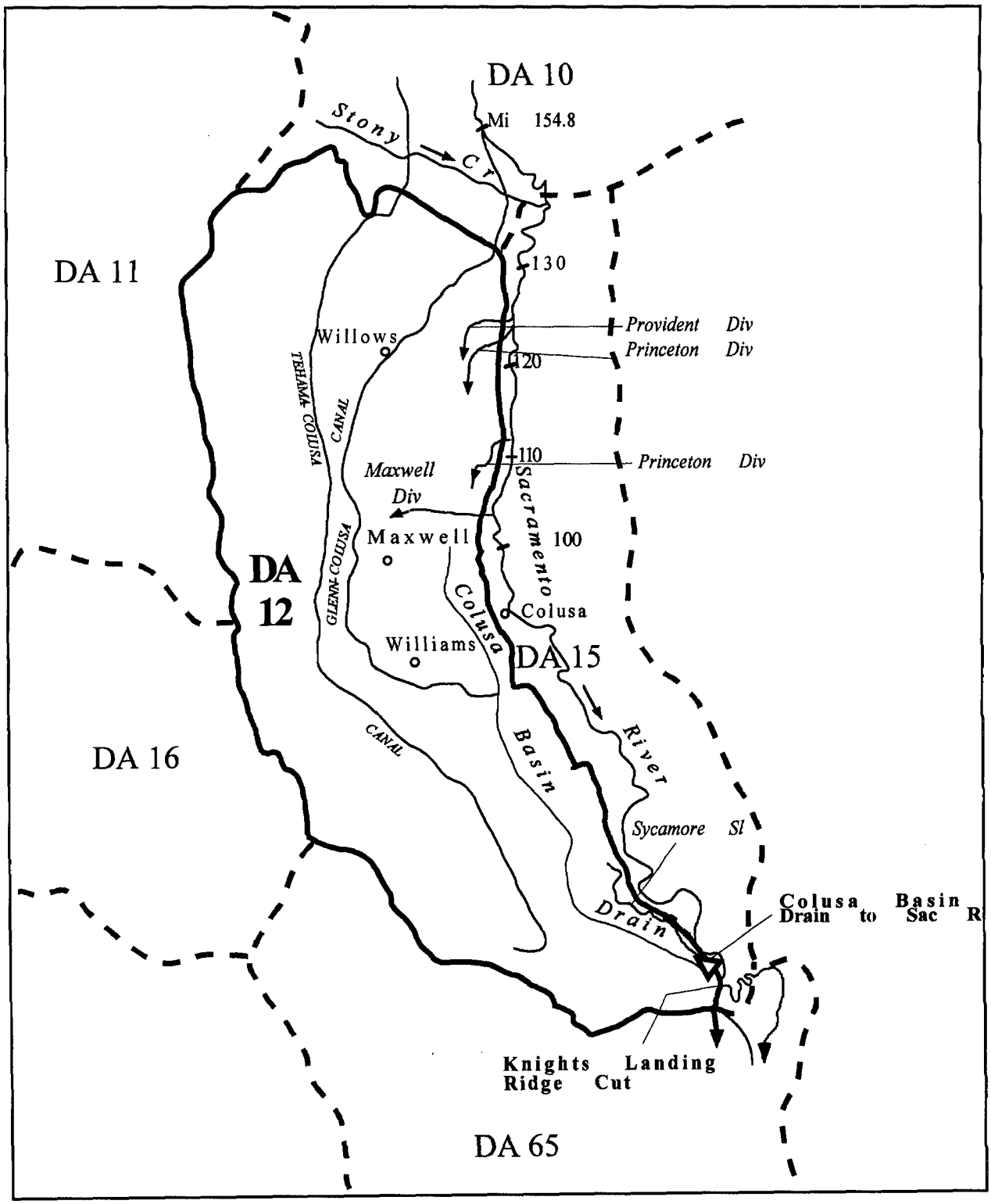


Figure 11: Depletion Area 12 Map

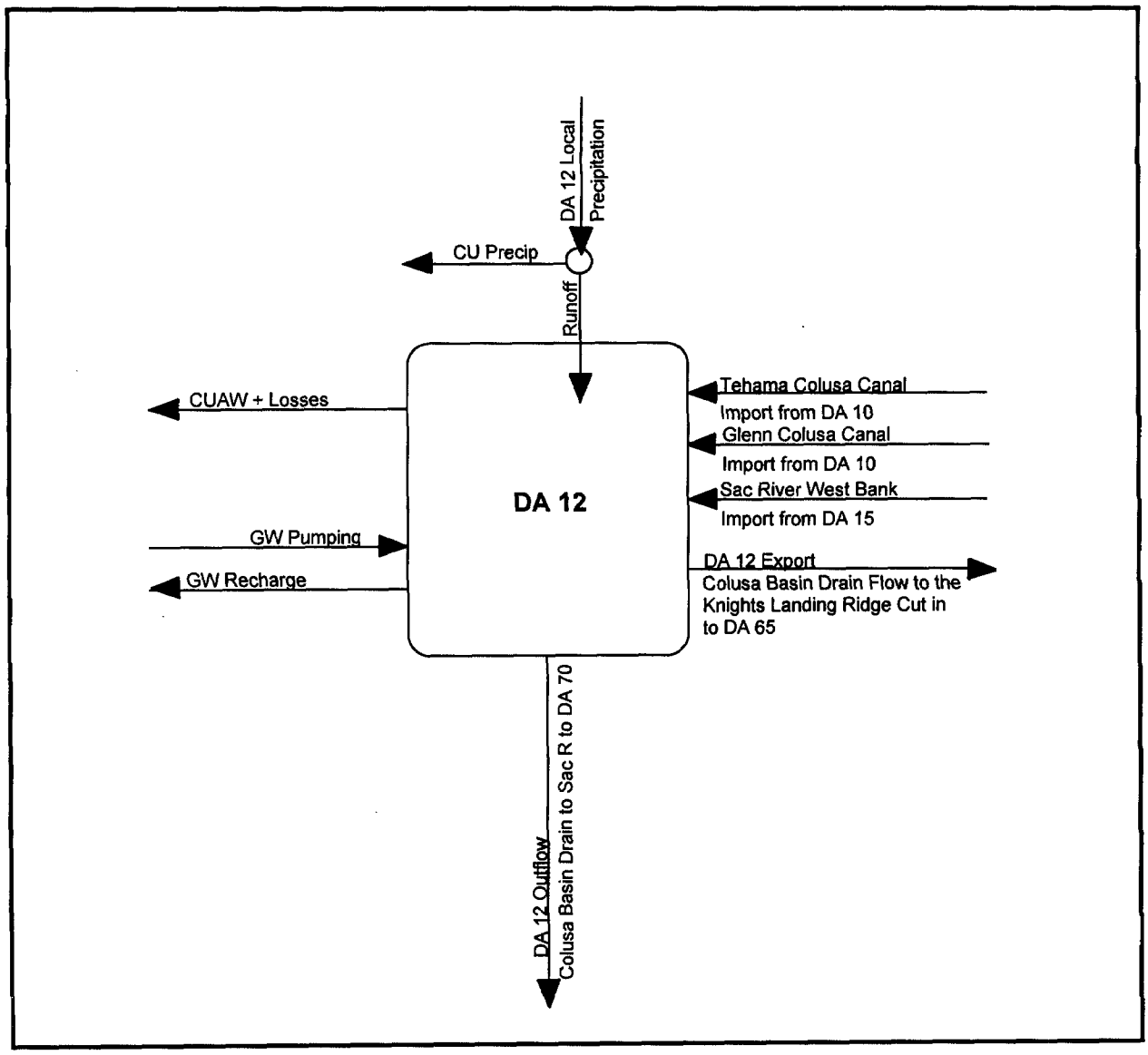


Figure 12: Depletion Area 12 Schematic

DEPLETION AREA 14
SACRAMENTO VALLEY EASTSIDE, CHICO LANDING TO FEATHER RIVER

Depletion Area 14 is the drainage area for Butte Creek and Little Chico Creek above Chico. DA14 is bounded by DA65 on the west side and by DA17 on the east side. Paradise Res. is the only reservoir located in DA14.

PROJECTED OUTFLOW: The projected outflow of DA 14 is the same as the historic flow

HISTORIC OUTFLOW: The historic outflow of Depletion Area 14 is calcualted as the sum of the flow of Butte Creek near Chico and the estimated flow of the unmeasured streams from Big Chico Creek to the Feather River. For the period October 1921 through September 1954, flows for Butte Creek near Chico were taken from Table 22 of the 1957 Joint Hydrology Study report. Flows for the unmeasured streams were taken from Table 35 of the same report. Beginning October 1954, Butte Creek flows were taken from USGS Water Resources Data reports. Unmeasured flows from Big Chico Creek to the Feather River were estimated to be 70.4% of the monthly flows of Antelope Creek near Red Bluff.

The monthly flows for Antelope Creek near Red Bluff for the period of October 1980 to September 1982 were taken from USGS Water Resources Data reports. Beginning October 1982 to September 1991, monthly flows were estimated using Linear Correlation with Mill Creek.

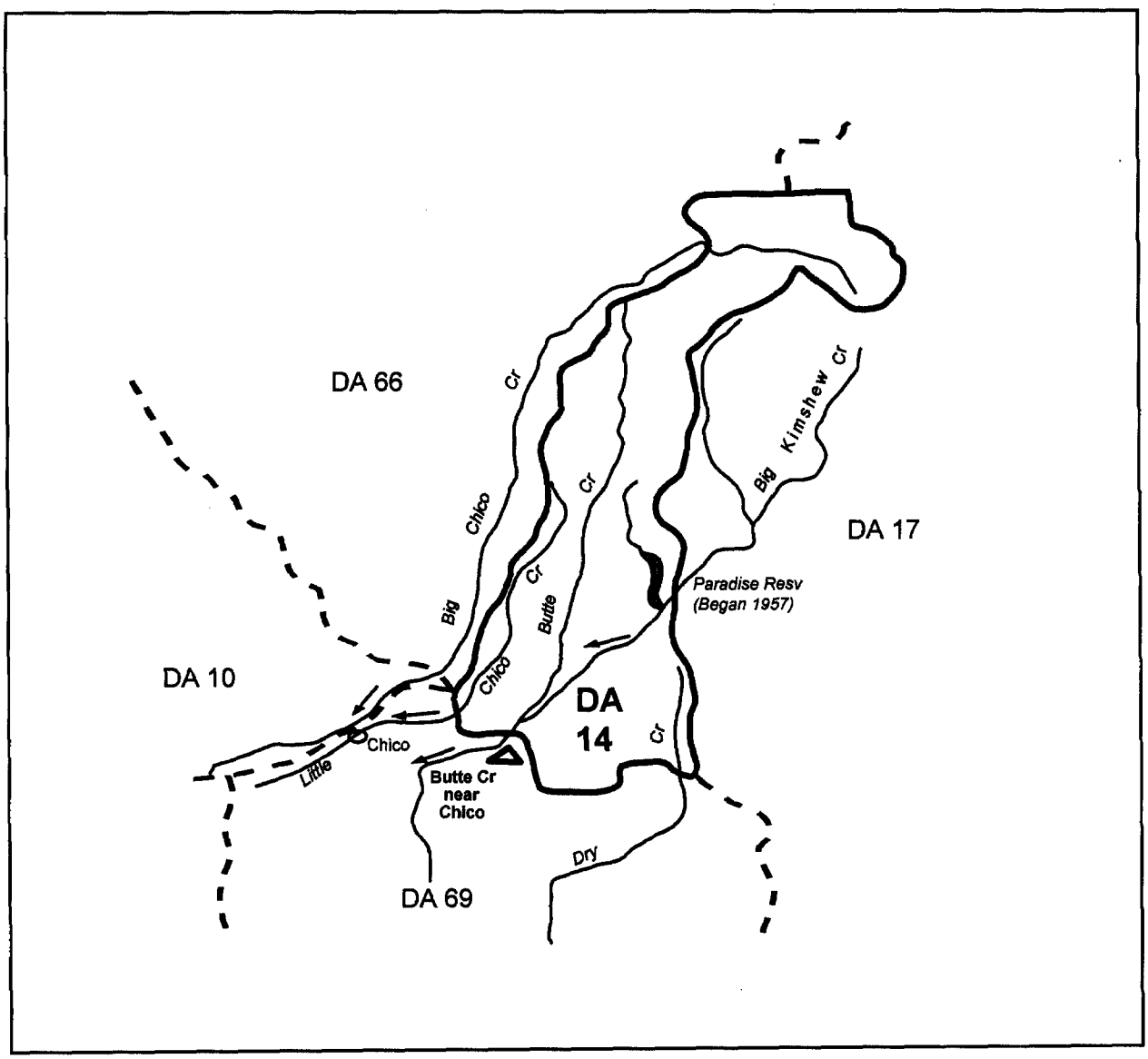


Figure 13: Depletion Area 14 Map

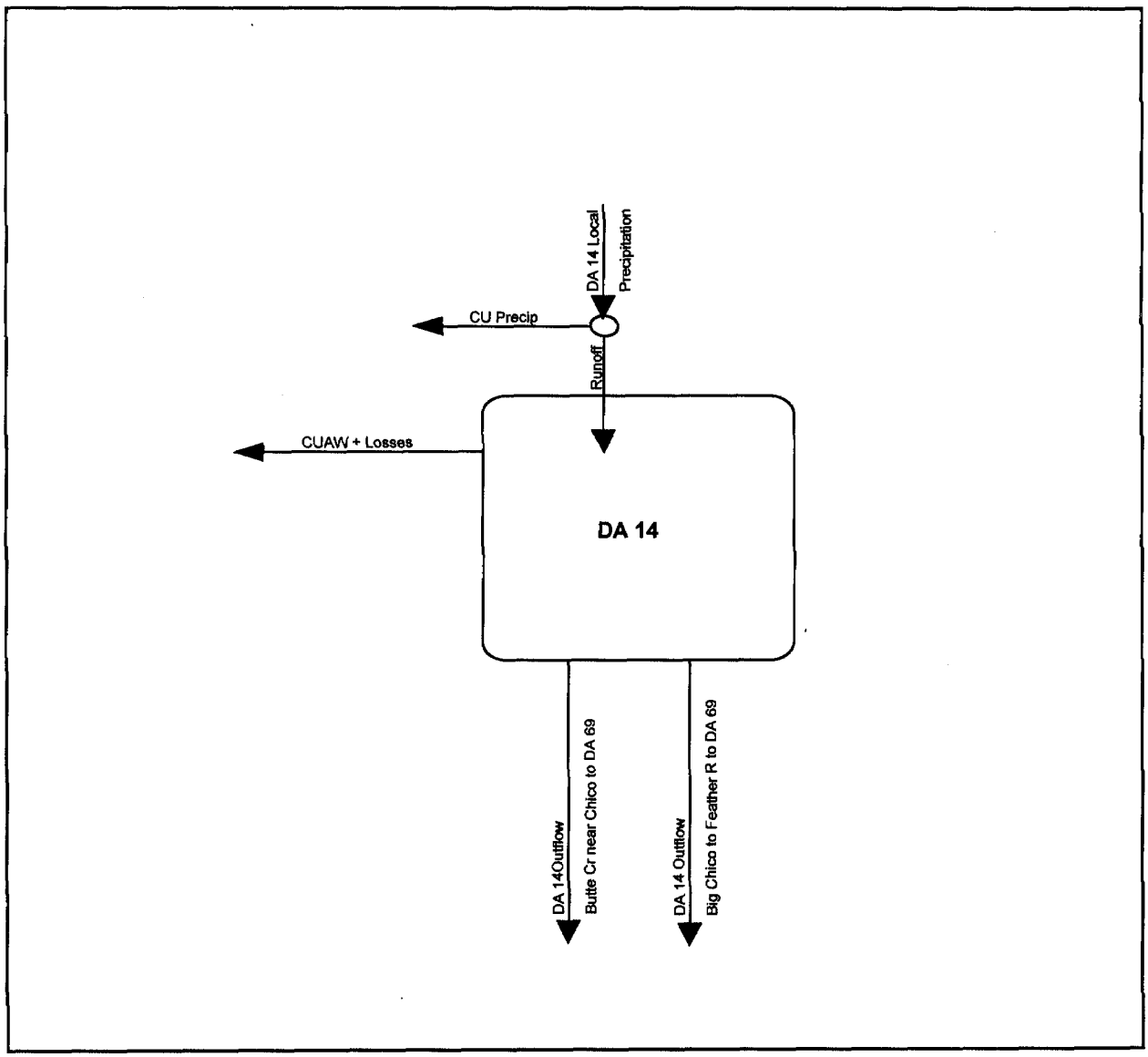


Figure 14: Depletion Area 14 Schematic

DEPLETION AREA 15
SACRAMENTO R. SERVICE AREA -CHICO LANDING TO KNIGHTS LANDING

Depletion Area 15 is located just downstream from DA10 and covers the reach of the Sacramento River between Knights Landing and Ord Ferry. Outflow gage is called Colusa Basin Drain joins the Sacramento River.

The exports in DA15 consists of Reclamation District 1500 Drain to Sutter Bypass in DA69 and Sacramento River west bank diversions to DA12.

PROJECTED OUTFLOW is calculated as:

+ Historic Outflow
+ Historic Export
- Projected Export
+ Upstream Area Modification from DA10
+ Historic Depletion
- Projected Depletion
+ Projected Additional Ground Water Pumping
- Projected Additional Ground Water Recharge
+ Project Water

HISTORIC OUTFLOW: The historic outflow of Depletion Area 15 is calculated as the estimated flow of the Sacramento River above the mouth of the Colusa Basin Drain plus the bank overflow above Butte City plus the spills over Colusa, Moulton, and Tisdale weirs.

10/22 - 9/54 The historic flow of the Sacramento River above Colusa Basin Drain was taken from Table 66 of the 1957 Joint Hydrology Study report. Sacramento River bank overflows came from Table 42, Moulton Weir from Table 43, Colusa Weir from Table 44, and Tisdale Weir from Table 45 of the same report.

10/54 - 9/55 The historic flow of the Sacramento River at Knights Landing was used in place of Sacramento River above Colusa Basin Drain. The Knights Landing flows are from USGS Water Resources Data reports.

Moulton, Colusa, and Tisdale weir flows are from DWR Water Supervision reports until water year 1977 when the reports were discontinued. Beginning water year 1977 these flows were obtained from the DWR Northern Office. The 1991 WY assumed zero.

10/55 - 9/92 Beginning water year 1955, Sacramento River bank overflows were estimated

using Plate 21 in the 1957 Joint Hydrology Study report. The graph relates the bank overflow to the Sacramento River at the Latitude of Chico Landing. The Sacramento River at Ord Ferry was used in place of the Sacramento River at Latitude of Chico Landing.

No bank overflow occurs when the Ord Ferry daily flow is less than 92,000 cfs.

HISTORIC EXPORT: DA15 exports include RD 1500 drain to Sutter Bypass in DA69 and Sacramento River west bank diversions to DA12.

RD 1500 drain flows for the period 10/21 through 9/54 were taken from Table 49 of the 1957 Joint Hydrology report. Flows for water years 1955 through 1976 were taken from DWR Water Supervision reports. Flows from 1977 through 1980 were obtained from the DWR Sutter Yard. WY 1987 thru-1990 were estimated as follows: Base = min. of actual and 22-86 monthly average Est. surplus = Total RD1500 Less base. Extended surplus for 87-90 by correlation with DA15 precip(3-sta).

Sacramento River west bank diversions to DA12 include Princeton-Cordora-Glenn I. D. diversions at miles 112.4, and 123.9; Maxwell diversion at mile 103.8; and Provident I. D. diversion at mile 124.2.

Sources of data for Sacramento River west bank diversions are as follows:

1922-23 Assumed equal to zero. 1924-75 DWR Water Supervision reports
1975-92 USBR Monthly Reports of Operations, Sacramento River Monthly Deliveries

PROJECTED EXPORT: Projected export for RD 1500 Drain to Sutter Bypass is the same as historic.

Projected export for Sacramento River west bank diversions to DA12 equal a normal year diversion of 141 TAF with 25% deficiencies in 1924 and 1931 thru 1934 and 50% deficiency in 1977. The normal year diversion of 141 TAF was developed from a USBR table by J. Maglinte, 5/26/89 of Sacramento River Water users.

The following is a breakdown of the export to DA12, in acre-feet:

Provident ID: Princeton-Cordora-Glenn Maxwell

Contract Base Supply	Project Supply	Total
49730	5000	54730

PROJECT WATER: Depletion Area 15 project water is the amount of stored water to be developed from upstream CVP reservoirs to help meet shortages to DA15's projected diversion

requirement and exports.

GROUND WATER PUMPING AND RECHARGE: The limited project water and reduced Sacramento River inflow is unable to meet all shortages. Remaining shortages are computed by the depletion analysis program as additional ground water pumping and recharge.

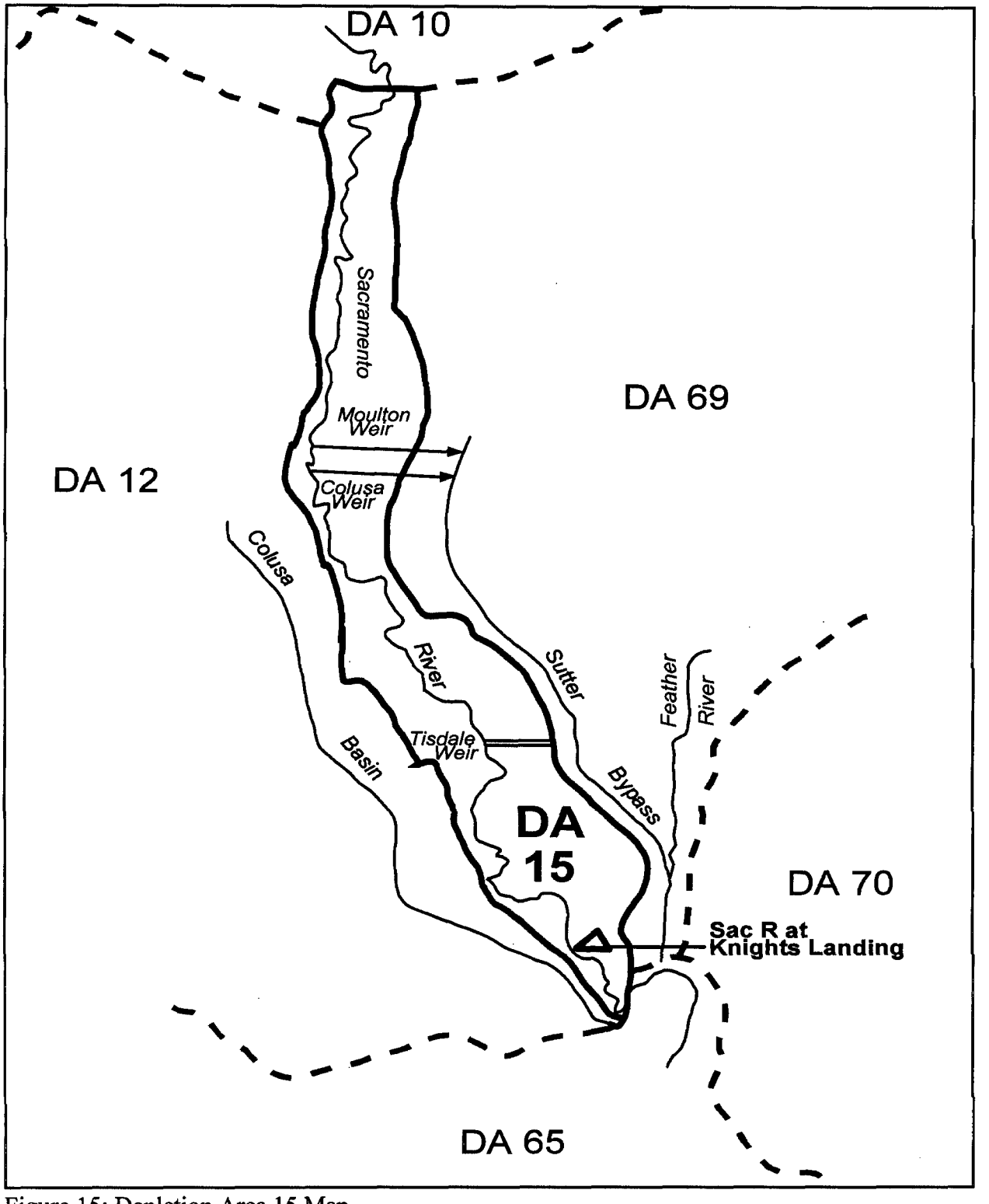


Figure 15: Depletion Area 15 Map

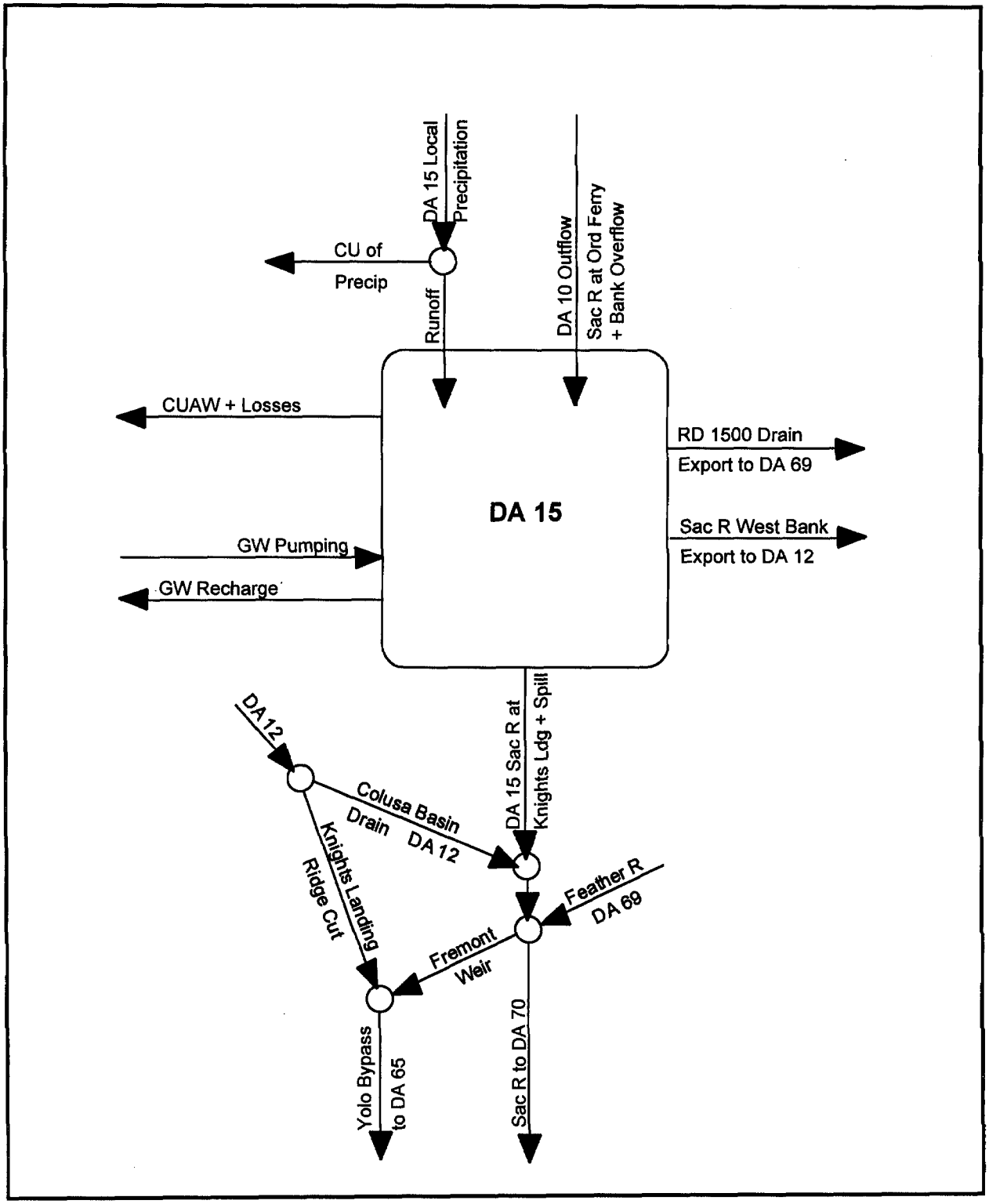


Figure 16: Depletion Area 15 Schematic

DEPLETION AREA 16
CACHE CREEK ABOVE RUMSEY

Depletion Area 16 is the drainage area for North Fork Cache Creek and Mill Creek and the portion of the Cache Creek above Rumsey. Clear Lake located at Lakeport is the major reservoir in DA16.

PROJECTED OUTFLOW: Projected outflow of DA16 equals the inflow to Blue Ridge Reservoir. The inflow was taken from a Blue Ridge Reservoir operation study computed 9/5/85 by Borcalli, Ensign and Buckley Consulting Engineers. Blue Ridge inflow was developed by CH2M Hill engineers in an operation study of Clear Lake and Indian Valley Reservoir.

HISTORIC OUTFLOW: Historic outflow of DA16 equals the flow of Cache Cr. above Rumsey.

10/21 - 9/65 Cache Creek above Rumsey was estimated as the sum of Cache Creek near Lower Lake, North Fork Cache Creek near Lower Lake, Bear Creek near Rumsey and accretions between Lower Lake and Rumsey.

Cache Creek near Lower Lake. Prior to May 1944 flows were estimated by DWR Northern District in 1969 from USBR and Clear Lake Water Company data. Beginning May 1944, flows were taken from USGS Water Resources Data reports.

North Fork Cache Creek near Lower Lake. Prior to July 1930 flows were estimated by correlation with the natural flow of the Eel River at Van Arsdale Dam. Beginning July 1930, flows were taken from USGS Water Resources Data reports.

Bear Creek near Rumsey. Prior to October 1958 flows were estimated by correlation with the North Fork Cache Creek near Lower Lake. Beginning October 1958, flows were taken from USGS Water Resources Data reports.

Accretions between Lower Lake and Rumsey. Incremental runoff between the three stations and Rumsey was estimated by correlation with the North Fork Cache Creek near Lower Lake.

10/65 - 9/91 The flow of Cache Creek above Rumsey was taken from USGS Water Resources Data reports.

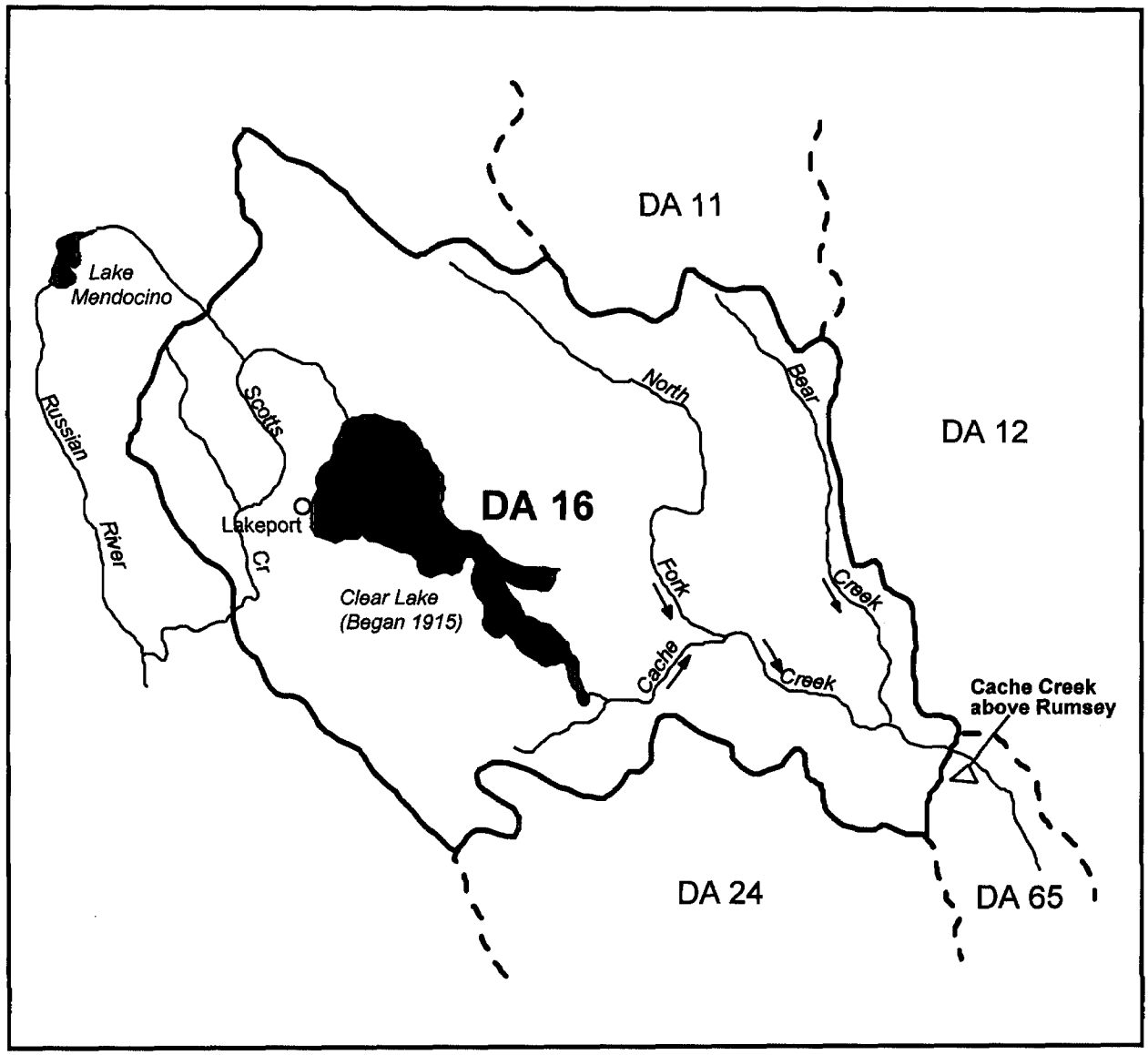


Figure 17: Depletion Area 16 Map

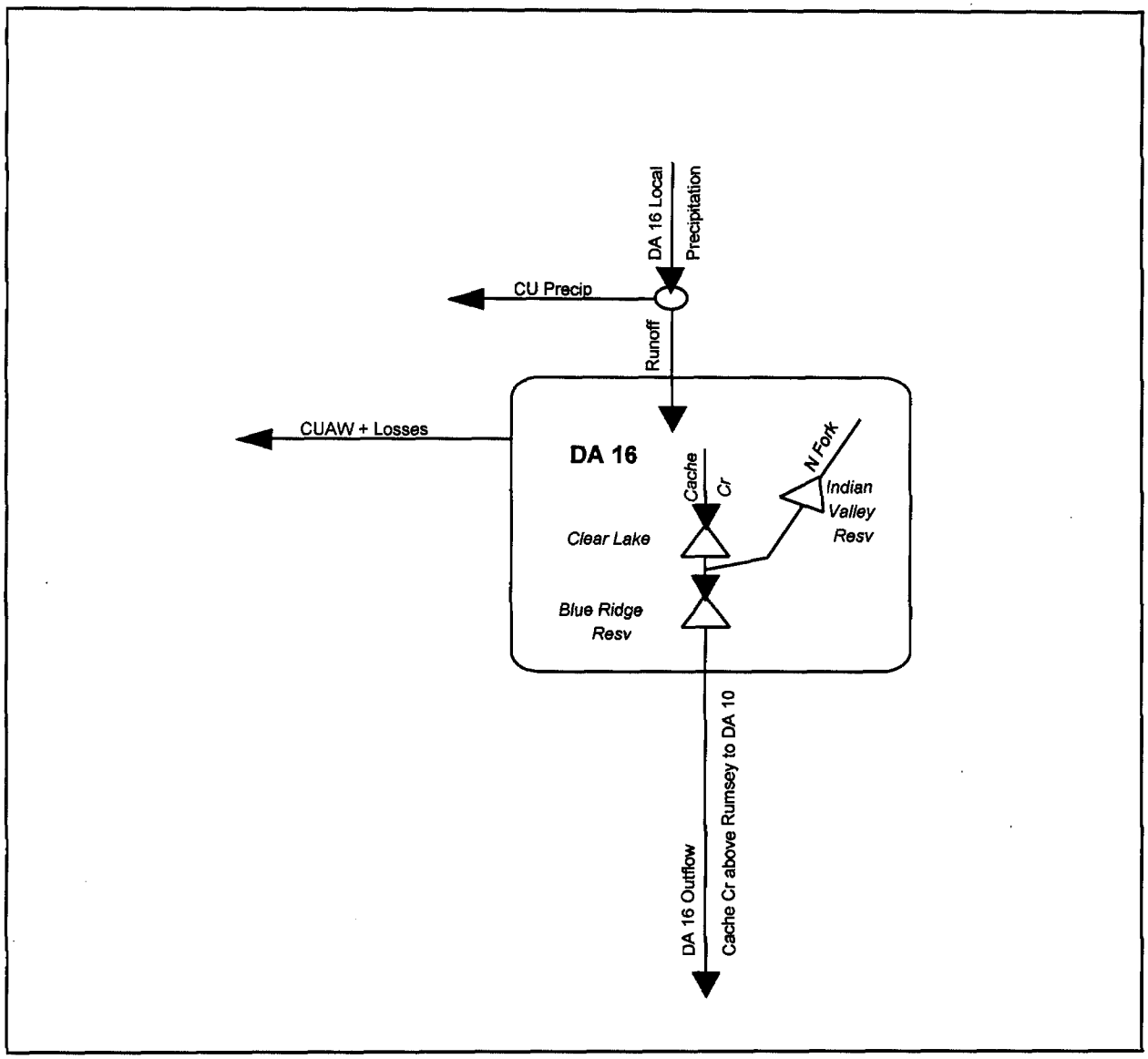


Figure 18: Depletion Area 16 Schematic

DEPLETION AREA 17
FEATHER RIVER INFLOW TO OROVILLE LAKE

Depletion Area 17 is the drainage area for the North Fork, Middle Fork, and South Fork of the Feather River. Lake Oroville and Lake Almanor are the major reservoirs in DA17.

The exports from DA17 are the sum of the flows in Hendricks, Miocene and Wilenor on the north side and Palermo, Forbestown Canals, and Miners Ranch canal on the south side.

PROJECTED OUTFLOW: The projected outflow of DA17 is equal to the projected inflow to Oroville Reservoir. The inflow includes water for Palermo Canal, but excludes return water from Kelly Ridge PH. Increases or decreases from historic depletions by irrigated lands are neglected.

Present level adjustments are made to the historic flow at Oroville for the period October 1921 - June 1969. After June 1969 Oroville inflow is assumed to be at present level.

Projected Outflow of Depletion Area 17 is calculated as:

+ Historic Outflow
+ Historic Export Miners Ranch Canal
- Projected Export Miners Ranch Canal
+ Historic Export Forbestown Ditch
- Projected Export Forbestown Ditch
+ Basin Modification OWID South Fork Feather River Project
+ Basin Modification PG&E North Fork Operation
+ Basin Modification Spring Valley Ditch and Lake Wilenor
+ Basin Modification Antelope Lake
+ Basin Modification Frenchman Lake
+ Basin Modification Lake Davis

HISTORIC OUTFLOW: Historic outflow is equal to the USGS gaged flow of the Feather River at Oroville.

10/21 - 9/34	Gage located just below Mountain Boulevard Bridge.
10/34 - 6/62	Gage located just below Oroville Damsite.
7/62 - 9/64	Gage located 200 feet below Mountain Boulevard Highway bridge.
10/64 - 6/69	Gage located 300 feet above the Thermalito diversion dam. Beginning

October 1967 the flow was adjusted for Oroville and Thermalito changes in storage, evaporation, and Thermalito diversions. Data for the period October 1967 - November 1968 was revised in the 1974 USGS Water Resources Data report.

7/69 - 9/80 The historic outflow is equal to the inflow to Oroville Reservoir as computed by the DWR Operations and Maintenance Division (O&M). Records for the period July 1969 - December 1975 are unpublished. Beginning January 1976 computed inflow was published in the DWR monthly Reports of Operations. Prior to July 1969 the historic outflow has been adjusted to include Palermo Canal. Monthly diversion data for Palermo Canal is from USGS Water Resources Data reports. For the period July 1963- September 1968 an additional amount of water from Kelly Ridge turnout to Palermo Canal was included. After June 1969, Palermo Canal is part of the historic inflow to Oroville Reservoir.

Kelly Ridge began operation in October 1962. An adjustment to subtract Kelly Ridge was made for the period October 1962 - June 1969 when the Feather River at Oroville gage was located downstream from Kelly Ridge. Prior to October 1966, Kelly Ridge return was estimated to be equal to Miners Ranch diversion minus 5% for losses minus delivery to Bangor Ditch minus turnout to Palermo Canal. Beginning October 1966, Kelly Ridge is listed in USGS Water Resources Data reports under Miners Ranch below Ponderosa Dam.

HISTORIC EXPORT MINERS RANCH CANAL: Historic Miners Ranch Canal diversion to DA69 began in October 1962. Data for the period October 1962 - September 1980 was obtained from USGS Water Resources Data reports.

PROJECTED EXPORT MINERS RANCH CANAL: Projected Miners Ranch Canal export was developed as follows:

10/21 - 12/27 Projected export was taken from computation sheets called "Net Effect on Delta and Historic Oroville Inflow" by Emmett Johnson, 6/14/66. The computation sheets are located in a 4-inch binder called "Area Modifications, 17-21" under the section called "OWID Mod. (Accretions Study)". According to the yellow draft documentation by E. J., 6-30-66, page 2, projected Miners Ranch for the years 1921 to 1927 were obtained from a 1958 study by Shell and Fleenor, "Feather River Basic Water with Kelly Ridge".

1/28 - 9/58 Projected export was converted to TAF/month from monthly diversion in cfs listed in a 1958 operation study, "South Fork Feather River Project", column

5, "Diversion to Miners Ranch Canal". The operation study is stored in a large envelope labeled "South Fork Feather River Project".

10/58 - 6/63 Projected export was obtained from an extension of the OWID operation study by Emmett C. Johnson in October 1969. The export is listed in column 38, "Diversion to Miners Ranch Canal".

7/63 -9/80 Projected export is assumed to be the same as historic.

HISTORIC EXPORT FORBESTOWN DITCH: Historic Forbestown Ditch export to DA69 is developed from estimated, published, and unpublished data, as follows:

10/21 - 12/23 Historic Forbestown Ditch is estimated by monthly correlation with Palermo Canal and South Fork Feather River at Enterprise.

1/24 - 9/27 Historic Forbestown Ditch was obtained from unpublished USGS records.

10/27 - 9/41 Historic Forbestown Ditch was obtained from USGS Water Resources Data reports. The diversion is listed under "Oroville-Wyandotte Canal near Clipper Mills".

10/41 - 9/53 Historic Forbestown Ditch was obtained from unpublished USGS records.

10/53 - 9/80 Historic Forbestown Ditch was obtained from USGS Water Resources Data reports.

PROJECTED EXPORT FORBESTOWN DITCH: Projected Forbestown Ditch export equals 14.5 TAF per year for the period October 1921 - December 1958. Beginning January 1959, the projected export is assumed to be the same as the historic.

BASIN MODIFICATION OWID SOUTH FORK FEATHER RIVER PROJECT OPERATION: The Oroville-Wyandotte Irrigation District (OWID) South Fork Feather River Project modification is calculatedas the projected minus historic effect of Little Grass Valley, Sly Creek, and Lost Creek reservoirs plus the increased import from Slate Creek in DA67.

10/21 - 12/27 The OWID modification is estimated by a similar year method using the 1928-58 OWID operation study described below.

1/28 - 12/58 The OWID modification is calculated as the projected minus the unimpaired flow of the South Fork Feather River at Palermo Dam. The projected and unimpaired flows for the period January 1928 - December 1941 are from an

OWID operation study developed 8/13/58 by F. E. Bonner, consulting engineer. Projected and unimpaired flows for the period January 1942 - December 1958 are from an extension of the operation study by DWR personnel in April 1960. ".

1/59 - 6/63 The OWID modification is calculated as the projected flow of the South Fork at Palermo Dam minus the historic flow South Fork Feather River at Enterprise minus the historic Palermo Canal diversion. The modification was computed from an extension of the OWID operation study by Emmett C. Johnson in October 1969.

6/63 - 9/80 OWID South Fork Feather River operation is assumed to be under full operation and the modification is equal to zero.

Exports for Forbestown Ditch and Miners Ranch Canal have been itemized separately.

BASIN MODIFICATION PG&E NORTH FORK OPERATION: October 1921 - May 1965. The historic effect of PG&E's North Fork operation was supplied by PG&E along with the projected effect described below. It is not known exactly what reservoir effects were included in the table; probably Lake Almanor, Mountain Meadows, Bucks Lake, and Butt Valley Reservoirs. Lake Almanor, Mountain Meadows, and Butt Valley were in operation before WY 1922. Bucks Lake began 1927. Several minor reservoirs were probably neglected. They include Grizzly Forebay (since 1928), Cresta Forebay (since 1949), Rock Creek Forebay (since 1950), and Poe Forebay (since 1958).

The projected effect of PG&E's North Fork operation was obtained from PG&E's FR-Y Operation Study presented as Plumas County Exhibit 17 at water rights hearings for Richvale Irrigation District's Middle Fork Feather River Project. Data from the the complete operation study or the impairments that make up the modification are not available. It is assumed that the table reflects the changes in storage and evaporation of Lake Almanor (capacity 1035 TAF), Mountain Meadows (capacity 24 TAF), Butt Valley (capacity 49.8 TAF), and Bucks Lake (capacity 101.7 TAF). The modification was probably calculated as the operated flow less the natural flow of the North Fork Feather River below Poe Powerhouse. In recent years Lake Almanor has been operated at the enlarged capacity of 1143 TAF. It would be preferable to obtain an operation study that would more closely reflect PG&E's current operation. In the absence of an 1143 TAF operation study, the FR-Y data is used thru May 1965 which is the time that Lake Almanor first filled to the FR-Y assumed capacity. After May 1965 the North Fork operation is assumed to be the same as historic.

BASIN MODIFICATION SPRING VALLEY DITCH AND LAKE WILENOR: Spring Valley Ditch (aka Wilenor Ditch) and Lake Wilenor (aka Concow Reservoir) are located on Concow

Creek which is tributary to the West Branch of the Feather River. The reservoir and ditch began operating in 1925.

10/21 - 12/24. The purpose of this modification is to extend the operation back to October 1921. The modification equals the 1928-52 average change in storage of Lake Wilenor minus the average export of Spring Valley Ditch to DA69. Lake Wilenor and Spring Valley ditch adjustment are described in more detail in a DWR Office Report entitled "Project Inflows to Oroville Reservoir" by Rod Hall, December 1964, revised July 1967. The modification was taken from blue ozalid computation sheets called "Adjustment to Feather River Near Oroville Flows", by Rod Hall, 8/26/64.

BASIN MODIFICATION ANTELOPE LAKE: Antelope Lake is located on Indian Creek, tributary to the East Branch of the North Fork of the Feather River. The storage capacity of Antelope Lake is 21.6 TAF. Initial storage began 11/63. Full operation is assumed after 1/65.

10/21 - 10/63 The modification is equal to minus the projected change in storage and evaporation of Antelope Reservoir from DWR Operation Study No. 11.

11/63 - 1/65 The modification equals the projected release minus the historic release from Antelope Reservoir. Projected releases were taken from DWR Operation Study No. 11. Historic releases equal the historic flow of Indian Creek near Indian Creek Guard Station. The historic flows were obtained from the DWR Water Supervision reports.

BASIN MODIFICATION FRENCHMAN LAKE: Frenchman Lake is located on Little Last Chance Creek, tributary to the Middle Fork of the Feather River. Reservoir storage capacity is 51.0 TAF. Initial storage began 11/61. Full operation is assumed after 4/65.

10/21 - 10/61 The modification is equal to minus the change in storage and evaporation of Frenchman Reservoir from Operation Study K8 by RD Testa, 8/11/67.

11/61 - 4/65 The modification equals the projected release minus the historic release from Frenchman Reservoir. Projected releases are from the Testa Operation Study K8. Historic releases equal the historic flow of Little Last Chance Creek below Frenchman Reservoir. The historic flow was taken from the DWR Water Supervision reports.

BASIN MODIFICATION LAKE DAVIS: Lake Davis is located on Big Grizzly Creek tributary to the Middle Fork of the Feather River. Reservoir storage capacity is 83.0 TAF. Initial storage began 12/66. Full operation is assumed after 4/69.

10/21 - 12/67	The modification is equal to minus the change in storage and evaporation of Lake Davis from Operation Study by Meade, 10/24/66.
1/68 - 4/69	The modification is equal to the Lake Davis projected releases minus the historic releases. Projected releases are from the Meade Operation Study. Historic releases equal the historic flow of Big Grizzly Creek at Grizzly Valley Dam near Portola. The historic flows for water year 1967 and 1969 were taken from USGS Water Resources Data reports. The historic flows for water year 1968 were taken from the DWR Water Supervision report.

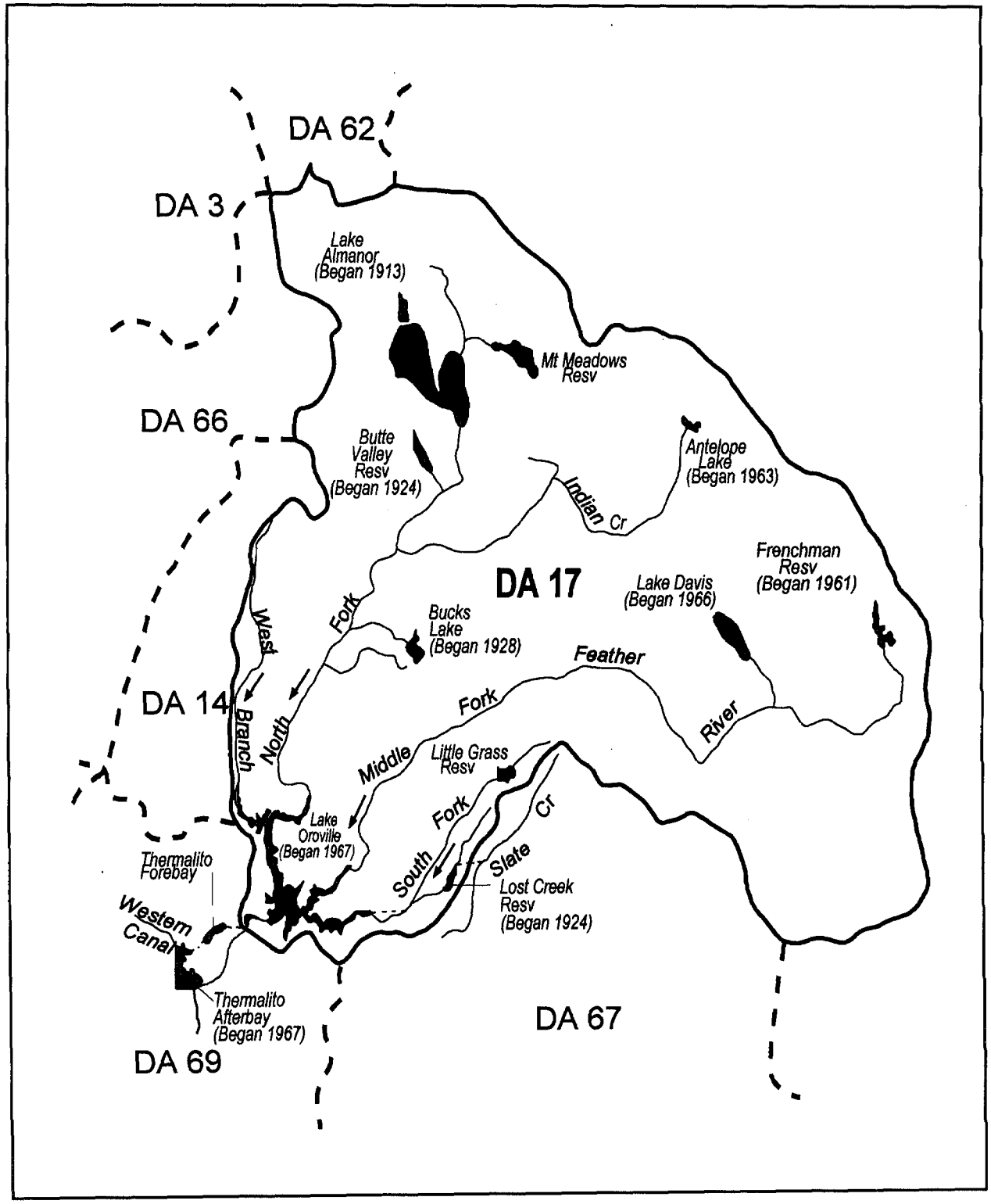


Figure 19: Depletion Area 17 Map

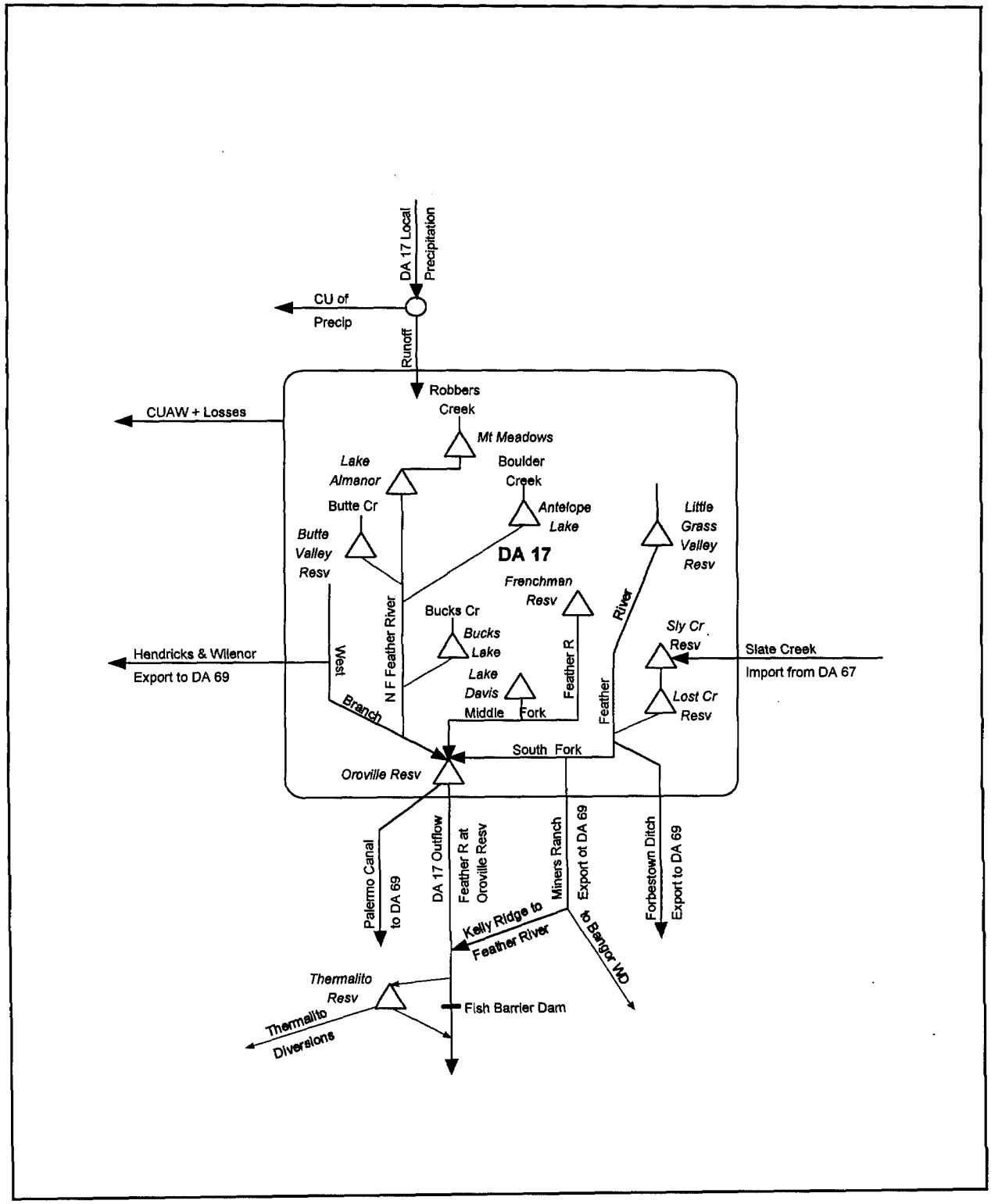


Figure 20: Depletion Area 17 Schematic

DEPLETION AREA 22
AMERICAN RIVER ABOVE FOLSOM RESERVOIR

Depletion Area 22 is the drainage area for American River above Folsom Lake. Folsom Lake is about 28 miles upstream from the mouth of the American River. The American River joins the Sacramento River at the city of Sacramento.

There are no areas upstream of this depletion area. The downstream area is DA70.

There are many reservoirs on the American River. Only the ten largest are modeled in DA22. The names and capacities are listed below:

Reservoir	Max Capacity (TAF)COMP	Comp. Date
Folsom Lake	1000.0	1956
Union Valley Reservoir	277.0	1962
Hello Hole Reservoir	208.4	1965
French Meadows Reservoir	133.7	1964
Loon Lake	76.5	1963
Ice House Reservoir	46.0	1959
Stumpy Meadows	20.0	1962
Caples Lake	21.6	1922
Silver Lake	11.8	1876
Lake Valley Reservoir	8.1	1911

There are many canal diversions on the American River. Many of the diversions transfer water from one upstream tributary to another for hydroelectric power generation. Two canals export water from DA22 to adjacent drainage basins. They are:

1. Lake Valley diversion from the North Fork American River to the Bear River, DA68.
2. Placer County Water Agency (PCWA) from the North Fork of the American River to

Auburn Ravine in DA70. This diversion was done once only in 1977 for emergency purposes. Auburn Ravine is a somewhat undefined area in the vicinity of Auburn and Roseville.

Three canals import water from adjacent drainage areas. They are:

1. South Canal from the Auburn Ravine area in DA70 to Newcastle Power Plant near Folsom Reservoir.
2. Camino Conduit (Sly Park) from the Cosumnes River drainage in DA25 to Weber Creek and Folsom Reservoir.
3. Echo Lake Conduit from the Lake Tahoe drainage area to the South Fork American River.

HEC3 MODELING: A depletion analysis is no longer performed on DA22. Instead, an HEC3 network and flow routing study is performed. In the study, the ten reservoirs, described above, are operated at present level (1990 level). The HEC3 model operates the reservoirs for the period 1922-80. After 1980, the upstream reservoirs are assumed to operate the same as they did historically.

The HEC3 storage operation for Folsom Reservoir is not used in the depletion analysis work for developing DWRSIM hydrology. Only the projected inflow to Folsom Reservoir (Control Point 12) and to Auburn Dam site (CP11) are used.

DA22 is upstream to DA70. The upstream area modification is calcualted as the projected minus historic inflow to Folsom Reservoir.

The projected inflow to Folsom Reservoir for the period 1922-80 is equal to the sum of the river flows at CP's 57 and 58 plus the PCWA diversion at CP11. After 1980, they are the same as the historic inflow.

The historic inflow to Folsom Reservoir beginning 1955 is equal to Folsom Reservoir historic releases plus change in storage and evaporation. Historic data is taken from USBR monthly reports of operations. Prior to 1955, before Folsom Reservoir was completed, the historic inflow equaled the American River at Fair Oaks minus an estimated accretions between Folsom and Fair Oaks plus estimated diversions for North Fork and Natomas Ditches.

The model is described in detail in a DWR Central District Memorandum Report dated March 1984. The network diagram for the model is included in Appendix A1.

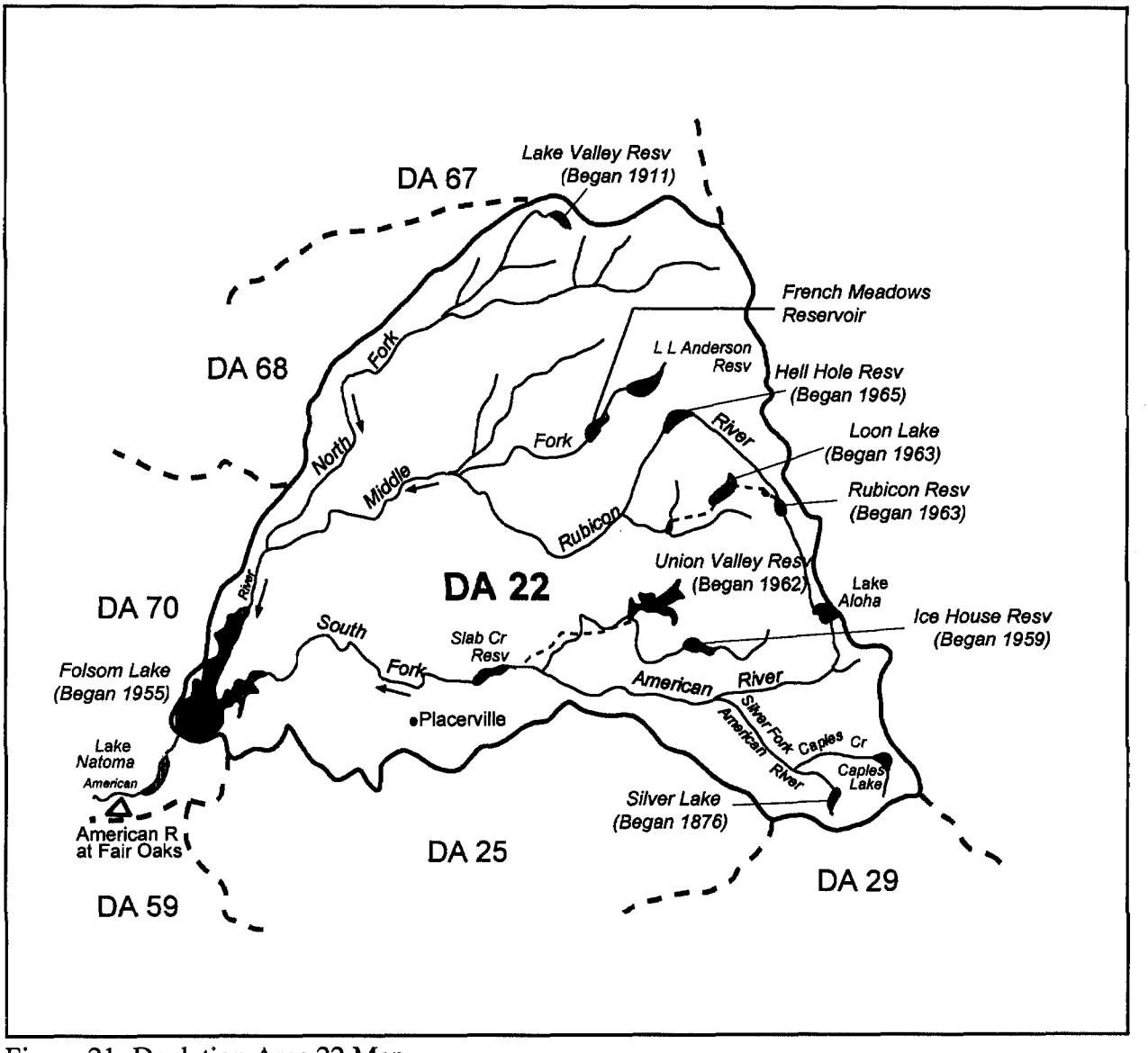


Figure 21: Depletion Area 22 Map

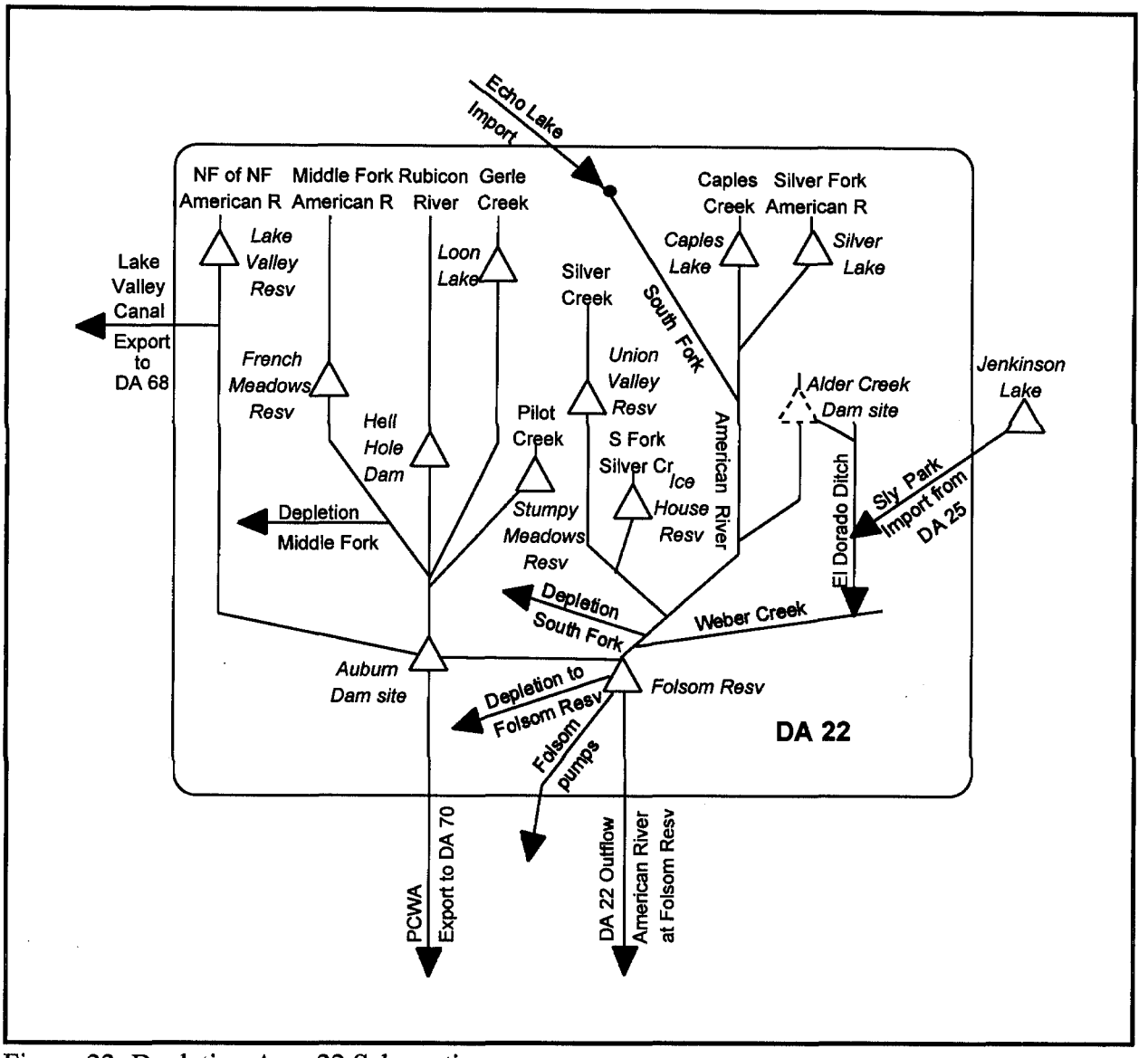


Figure 22: Depletion Area 22 Schematic

DEPLETION AREA 24
PUTAH CREEK NEAR WINTERS

Depletion Area 24 is the drainage area for the segment of Putah Creek above Winters, north of Lake Berryessa. Lake Berryessa is the major reservoir in DA24.

PROJECTED OUTFLOW: Projected outflow of DA24 equals the releases from a Lake Berryessa Operation Study developed by USBR, 3/27/80. The study assumes about 224 TAF/year for downstream prior rights, M & I, and agriculture. A demand of 12 TAF/year in November through March is assumed for upper basin depletion. The inflow was developed by USBR. Inflow compares closely to the DWR February 1987 unimpaired flow of Putah Creek near Winters

HISTORIC OUTFLOW: Historic outflow of Depletion Area 24 equals Putah Creek near Winters. Putah Creek near Winters gage is located 1.3 miles downstream from Monticello Dam. The gage is approximately 6 miles upstream from Putah South Canal diversion dam.

10/21 - 9/54	The historic outflow was taken from Table 28 of the 1957 Joint Hydrology Study.
10/54 - 9/91	Historic outflow of the Putah Creek near Winters was taken from USGS Water Resources Data reports. The monthly flows were unadjusted for Lake Berryessa.

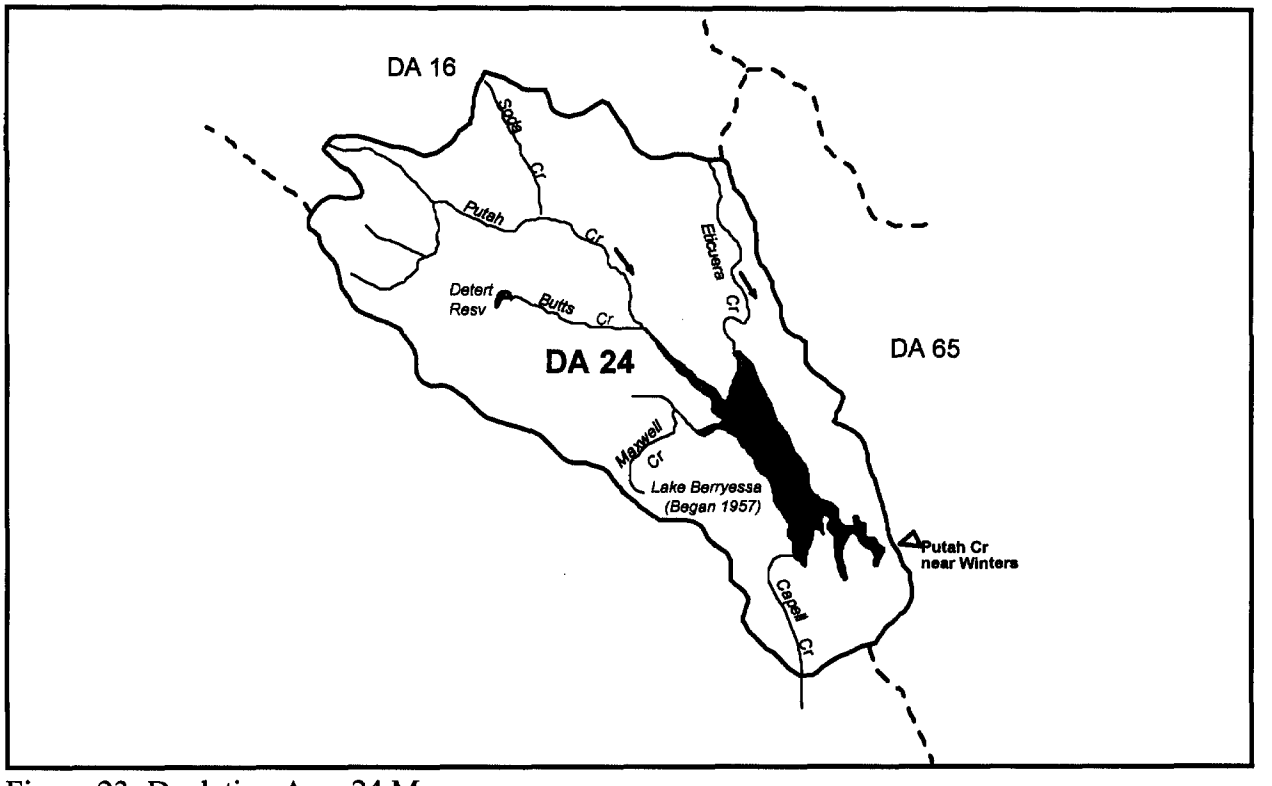


Figure 23: Depletion Area 24 Map

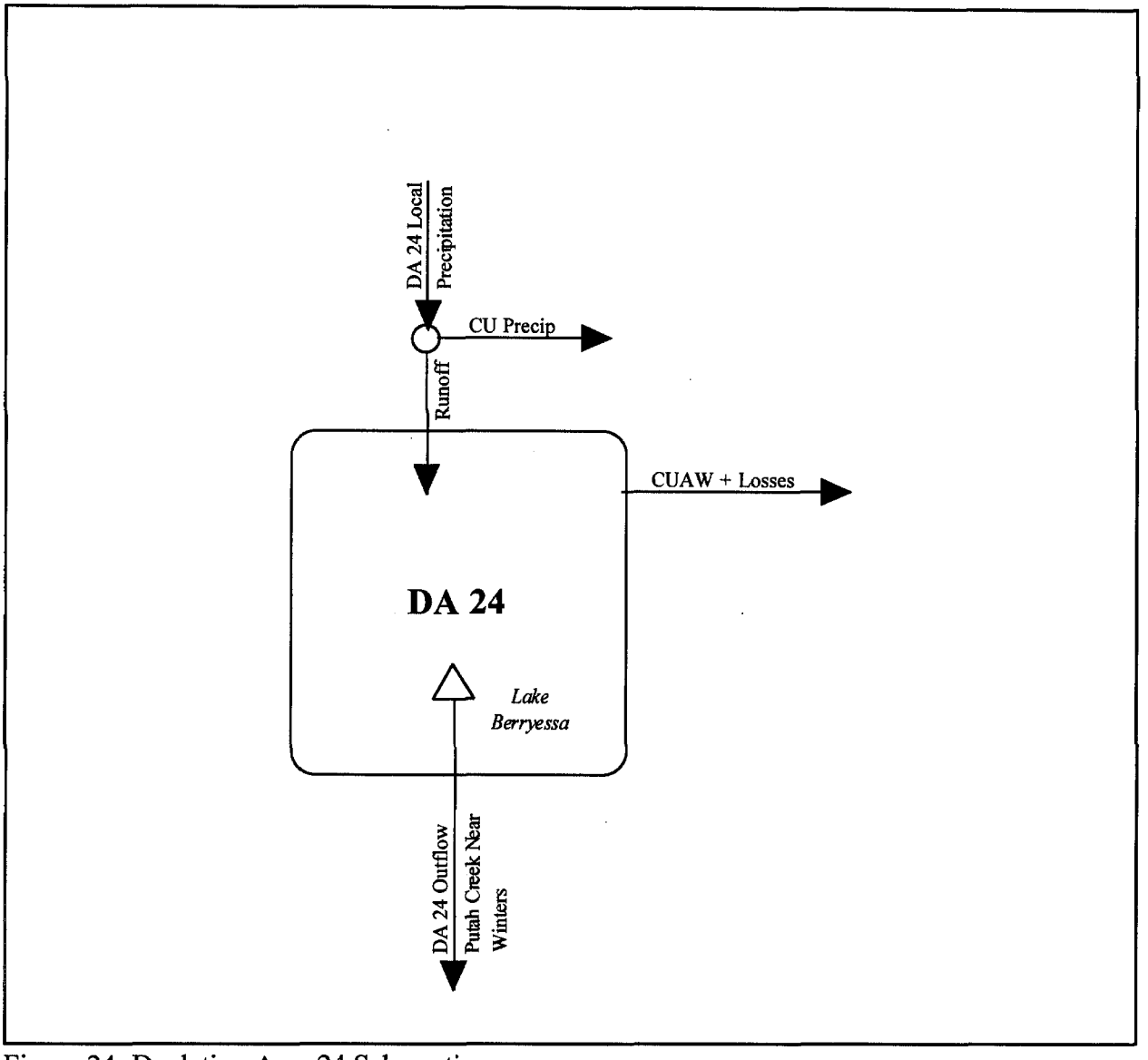


Figure 24: Depletion Area 24 Schematic

DEPLETION AREA 25
COSUMNES RIVER

Depletion Area 25 is the drainage area for the North Fork, Middle Fork, and South Fork of the Cosumnes River and Deer Creek. The outflow gage is located on the Consumnes River at Michigan Bar. The only export in DA25 is the Sly Park (Camino) Conduit from Jenkinson Lake to DA22.

HISTORIC OUTFLOW: Historic outflow of DA25 is defined as the Cosumnes River at Michigan Bar. Monthly flows were taken from USGS Water Resources Data reports. Runoff of Deer Creek near Sloughhouse and unmeasured areas, previously included in DA25 outflow, were excluded in this depletion study. DA25 boundary has been changed to encompass only the drainage area above the Cosumnes River at Michigan Bar. The Deer Creek and the unmeasured area are, now, part of DA59.

HISTORIC EXPORT: Historic export equals Sly Park (Camino) Conduit from Jenkinson Lake to DA22. Values were taken from USGS Water Resources Data reports listed at the bottom of the table for Camp Creek near Somerset flows.

PROJECTED EXPORT: The projected export equals estimated 1990 level diversion of Sly Park (Camino) Conduit from Jenkinson Lake to DA22. Sly Park export was estimated by water year classification.

BASIN MODIFICATION: Basin modifications for DA25 are calculated as projected minus historic changes in Cosumnes River flows due to Sly Park project plus projected minus historic Sly Park export plus increased El Dorado ID import from Folsom Lake, DA22.

Projected changes in Cosumnes River flows were taken from Table 27 of the USBR Hydrology Appendix for the Initial Phase Cosumnes River Division report of October 1967. Projected Sly Park export was estimated to be 23 TAF/year. Historic changes in Cosumnes River flows due to Jenkinson Lake and Sly Park diversion began in October 1954. Beginning October 1965 modification for Sly Park was assumed to be zero.

Increased EID import is calcualted as the projected minus historic El Dorado ID diversion from Folsom Lake. Projected import is part of Folsom Pumps diversion at control point 12 in the American River HEC Operation Study. The projected import equals the EID Direct Lake Diversion listed in the 4/8/84 RHZ table of American River Demands. Historic EID Folsom Lake diversion began in July 1965. Its diversion of less than 500 acre-feet/month was neglected for the entire period.

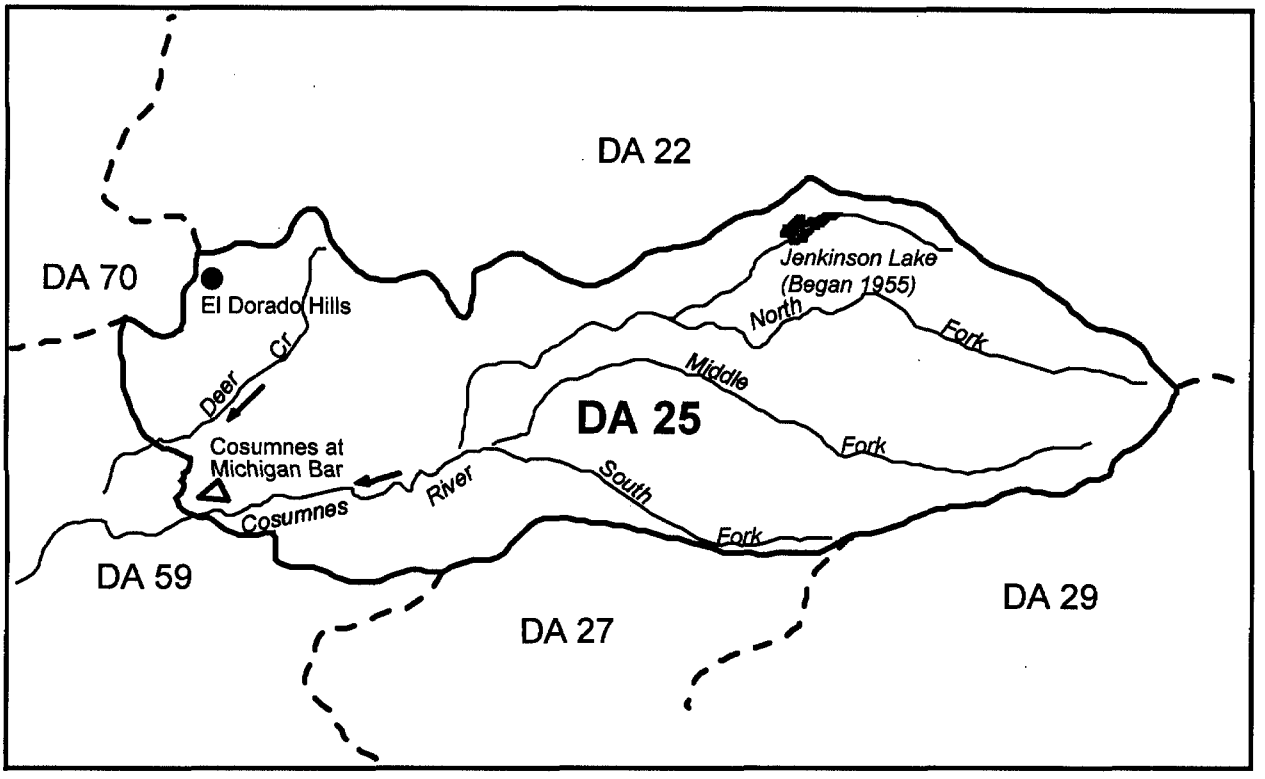


Figure 25: Depletion Area 25 Map

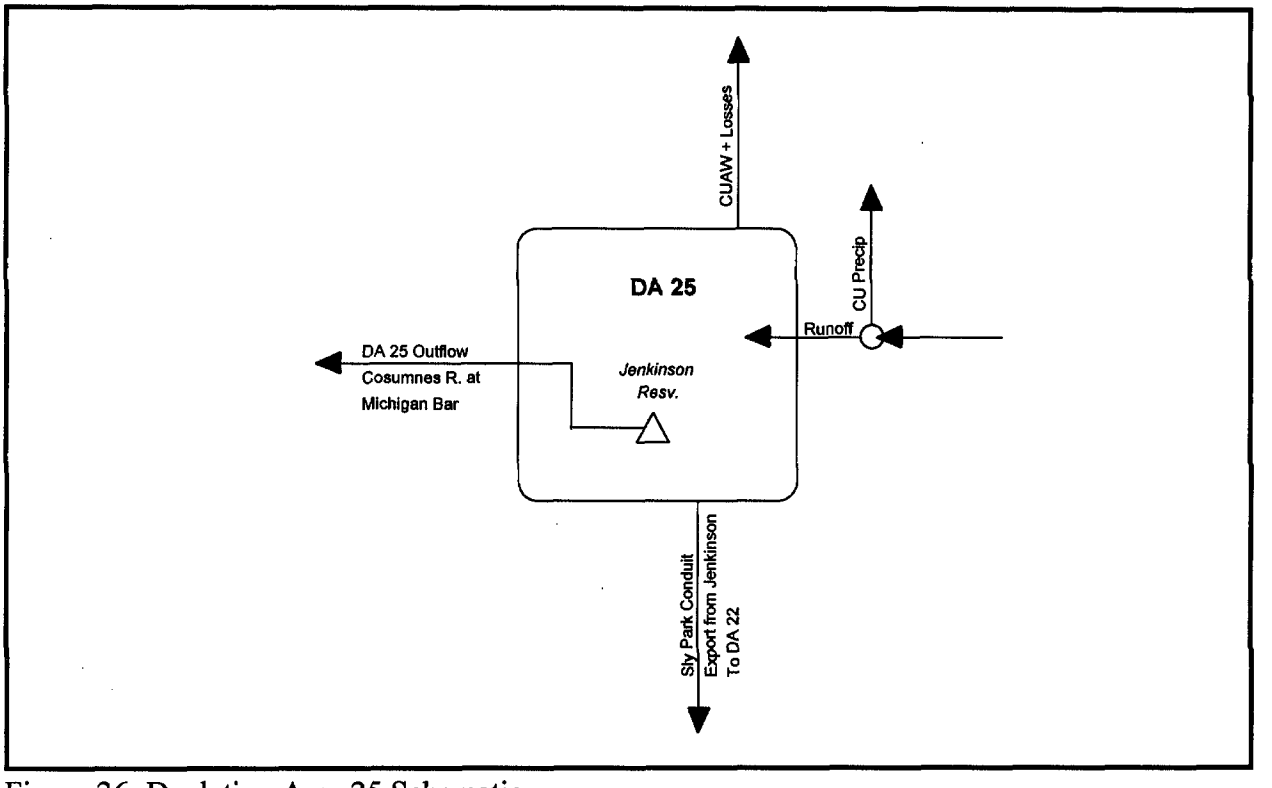


Figure 26: Depletion Area 25 Schematic

DEPLETION AREA 27
DRY CREEK

Depletion Area 27 is the drainage area for Sutter Creek and South Fork Dry Creek. It is located on the south side of DA25 and the northeast side of DA59.

PROJECTED OUTFLOW: The projected outflow of DA27 is the same as the historic flow.

HISTORIC OUTFLOW: The historic outflow of Depletion Area 27 represents the runoff of the Dry Creek drainage area at a line crossing Dry Creek about 6 miles above the Dry Creek near Ione gage.

10/21 - 9/60	Runoff is estimated as [0.85 * (estimated and measured Dry Creek near Ione)]. Measured runoff was taken from USGS Water Resources Data reports for the period January 1926 - September 1932. The periods January 1921 - December 1925 and October 1932 - September 1960 were estimated by correlation with Dry Creek near Galt.
10/60 - 9/70	Estimated as [0.64 * (combined runoff of Dry Creek above Sutter Creek near Ione and Sutter Creek near Sutter Creek)].
10/70 - 9/91	Estimated by the same method as 10/21 - 9/60.

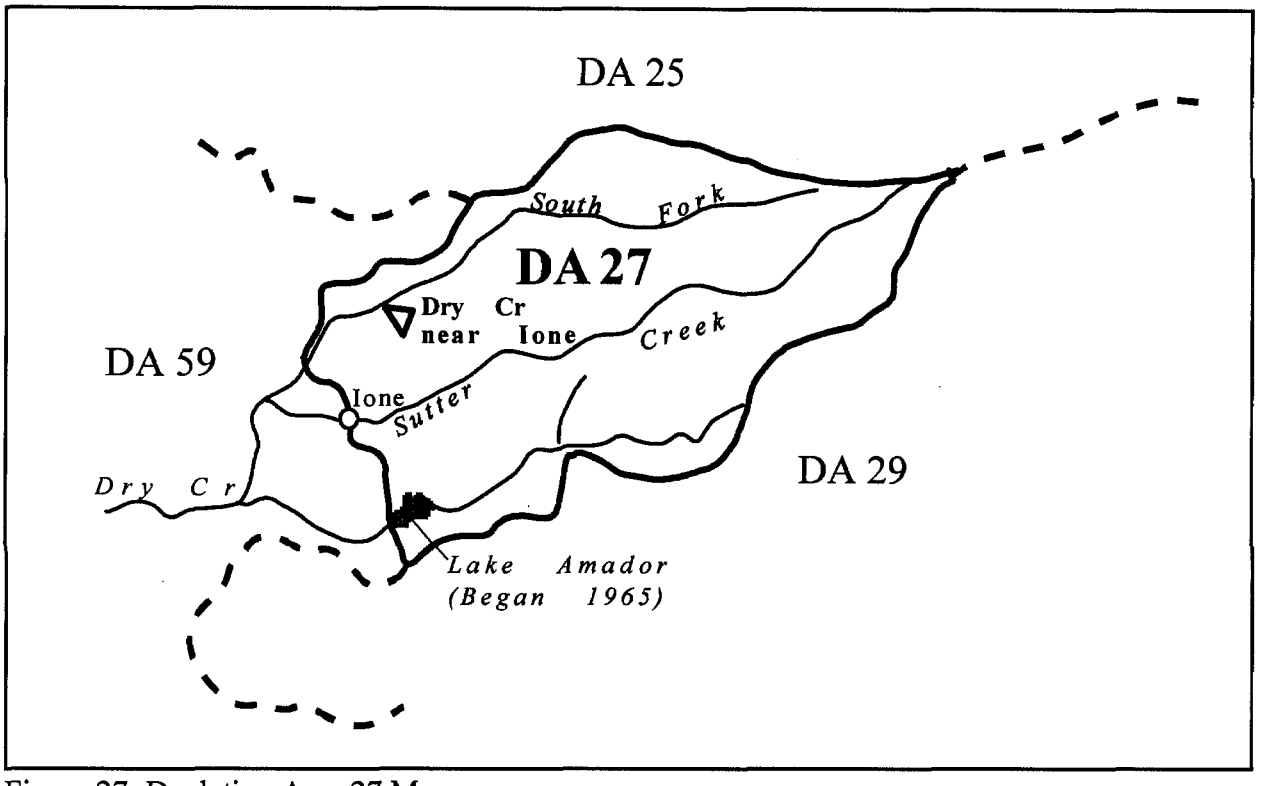


Figure 27: Depletion Area 27 Map

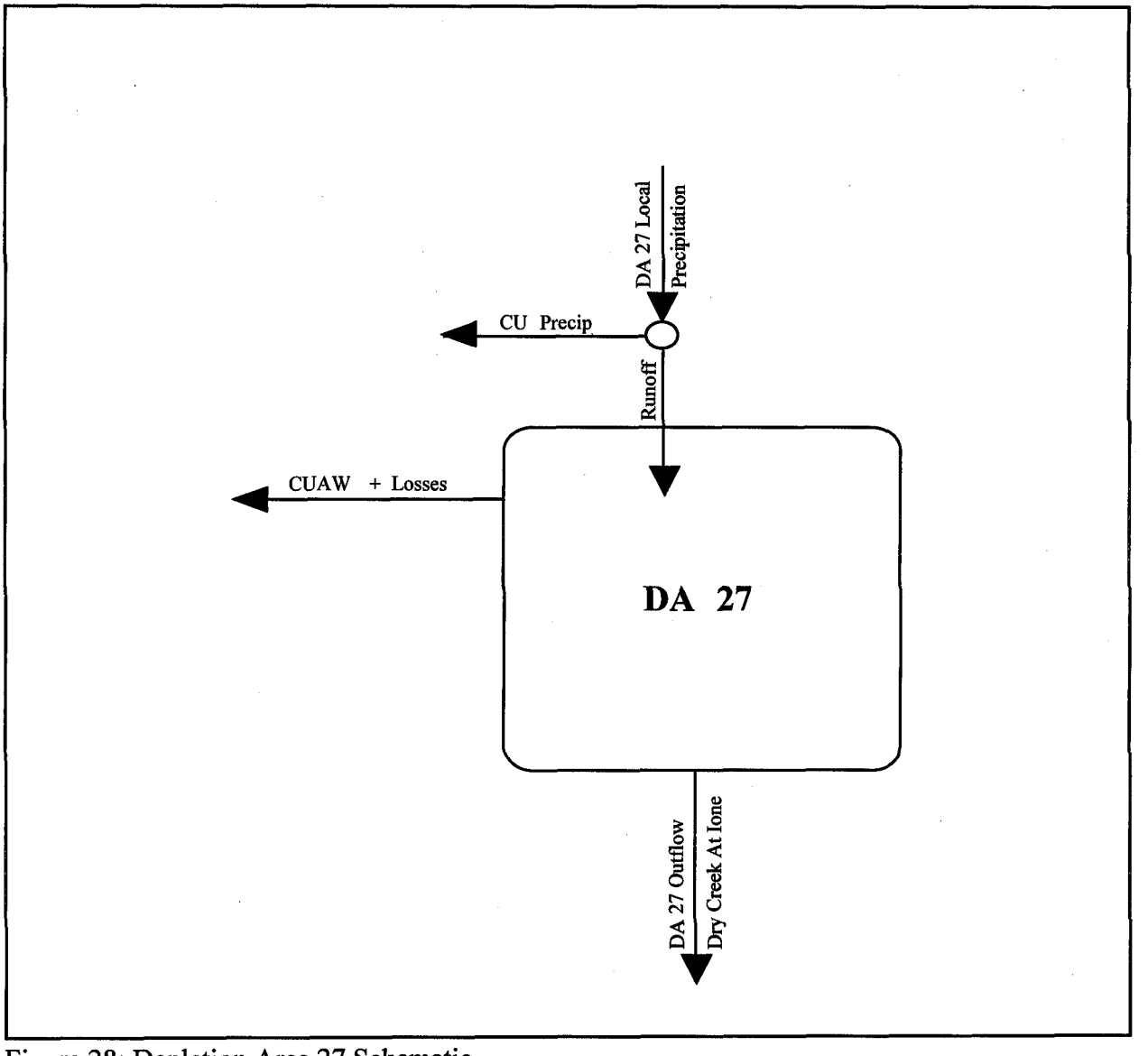


Figure 28: Depletion Area 27 Schematic

DEPLETION AREA 29
MOKELUMNE RIVER

Depletion Area 29 is the drainage area for the North Fork, Middle Fork, and South Fork Mokelumne River from its northernmost point to Pardee Reservoir. Camanche and Pardee are the two major reservoirs located in DA29.

The exports from DA29 consists of releases from Pardee reservoir into EBMUD Mokelumne Aqueduct, diversions by Jackson Valley Irrigation District from Pardee Reservoir, and diversions by the Amador and Mokelumne Hill ditches.

PROJECTED OUTFLOW: The projected outflow is defined as the total releases from Camanche Reservoir as computed in a 5/9/85 reservoir operation study by EBMUD. The study is identified as #84 325 7.23.

HISTORIC OUTFLOW: The historic outflow of DA29 equals the monthly flow of the Mokelumne River below Camanche Reservoir. Flows were taken from USGS Water Resources Data reports as follows:

10/21 - 9/26	Mokelumne River near Clements
10/26 - 9/63	Mokelumne River at Lancha Plana
10/63 - 9/91	Mokelumne River below Camanche Dam, unadjusted.

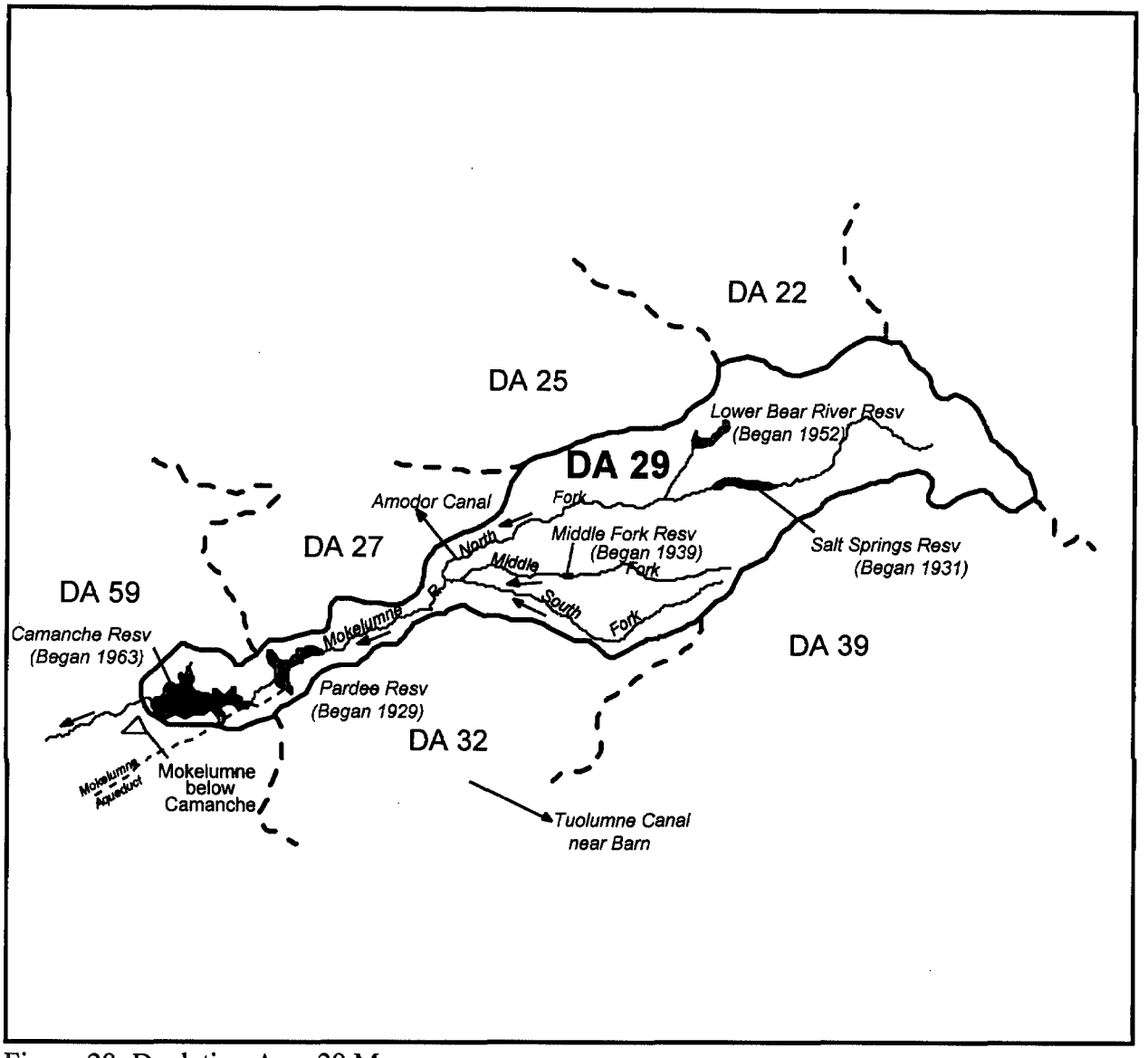


Figure 29: Depletion Area 29 Map

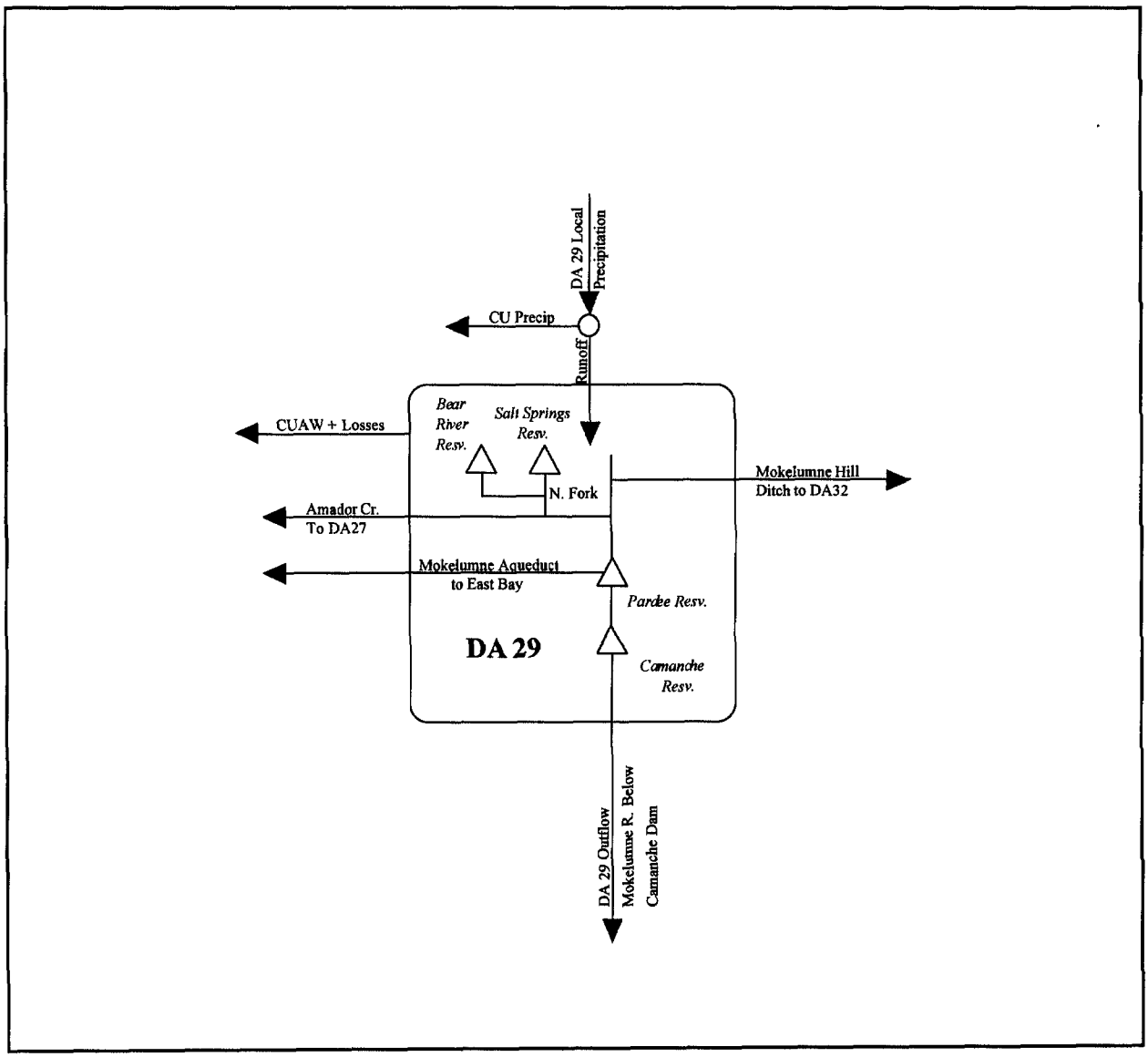


Figure 30: Depletion Area 29 Schematic

DEPLETION AREA 32
CALAVERAS RIVER

Depletion Area 32 is the drainage area for the North Fork and South Fork Calaveras River. It is located on the southeast side of DA59. New Hogan Lake is the major reservoir located in DA32.

PROJECTED OUTFLOW: The projected outflow was taken from a New Hogan Reservoir operation study. The study was developed by Murray, Burns, and Kienlen and covers the period 1921 through 1963. The study was extended by DWR personnel through 1971. Beginning October 1971, the projected outflow was assumed the same as historic.

HISTORIC OUTFLOW: The historic outflow of DA32 equals the monthly flow of the Calaveras River at Jenny Lind. Flows were developed from measured and estimated data as follows:

10/21 - 9/54	Taken from Table 111 of the 1957 Joint Hydrology Study report.
10/54 - 9/66	Taken from USGS Water Resources Data reports.
10/66 - 9/91	Estimated as the Calaveras River below New Hogan Reservoir plus 1.422 * Cosgrove Creek near Valley Springs. The Cosgrove Creek gage was discontinued September 1969 after which Cosgrove Creek runoff was estimated by correlation with Bear Creek near Lockford. Data for the Calaveras River, Cosgrove Creek, and Bear Creek flows were taken from USGS Water Resources Data reports.

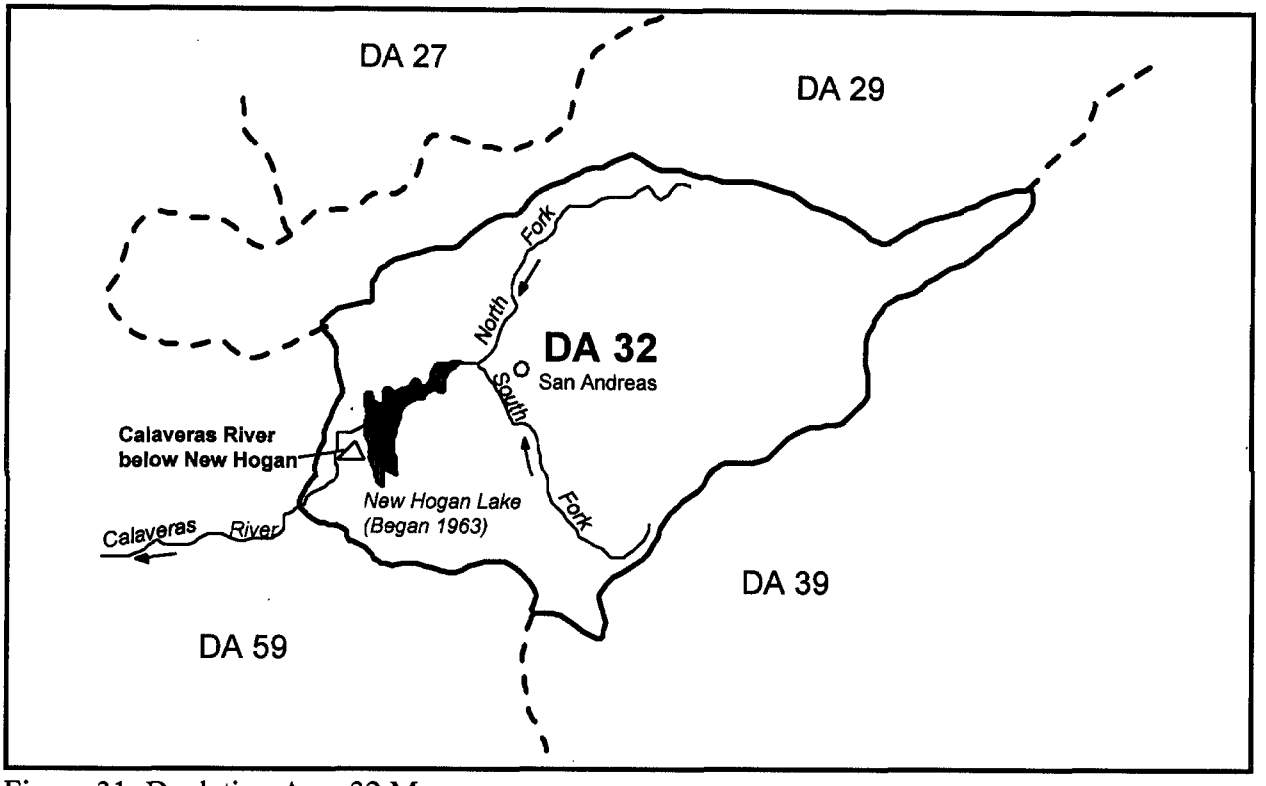


Figure 31: Depletion Area 32 Map

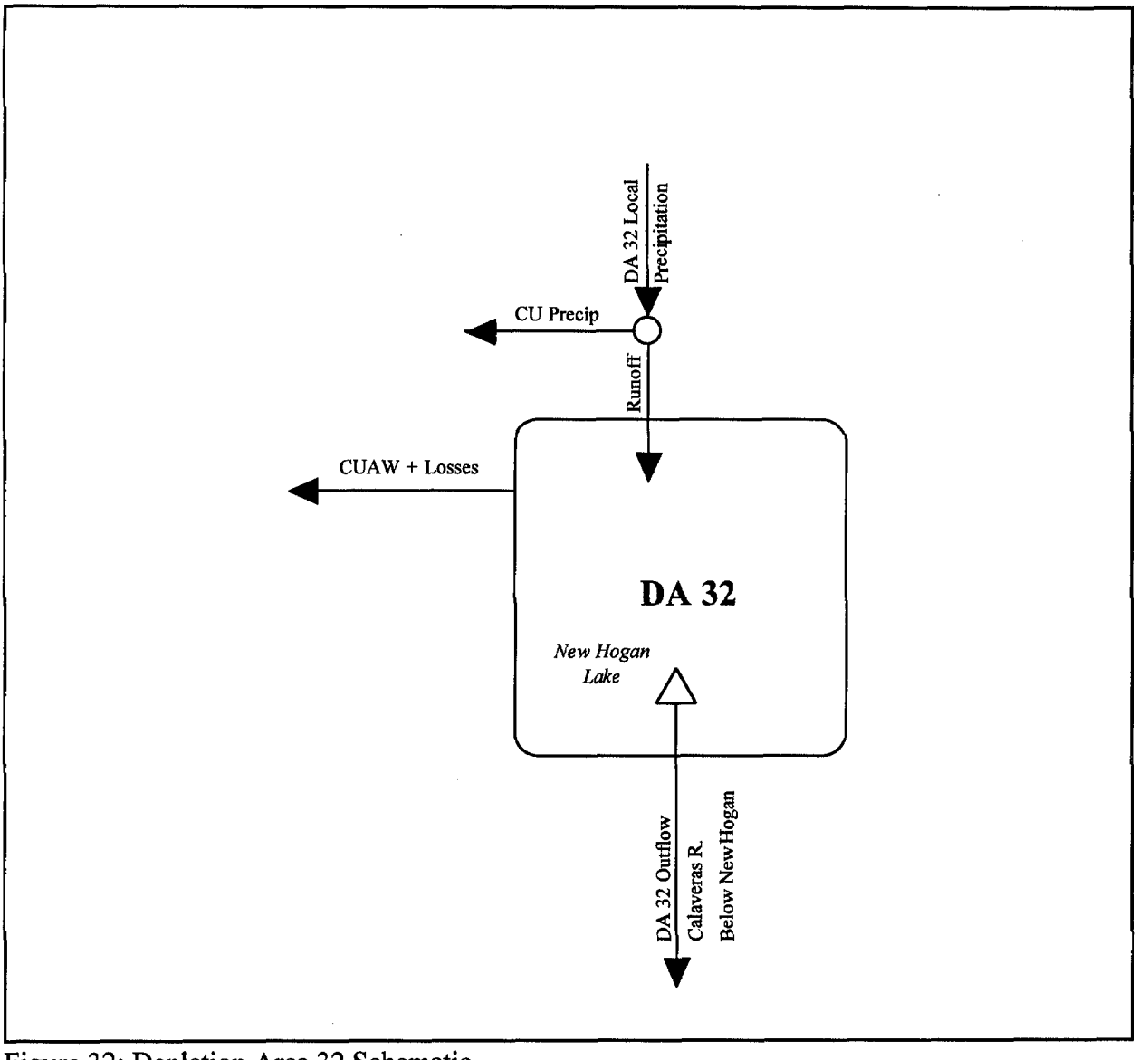


Figure 32: Depletion Area 32 Schematic

DEPLETION AREA 39
STANISLAUS RIVER INFLOW TO NEW MELONES RESERVOIR

Depletion Area 39 is the drainage area for the Stanislaus River from Tulloch Reservoir to the northernmost parts of the North Fork, Middle Fork, and South Fork Stanislaus River. Tulloch Reservoir and New Melones Lake are the major reservoirs in DA39.

PROJECTED OUTFLOW: A depletion study was not run for this area. The projected outflow is calculated as unimpaired flow Stanislaus River at New Melones Reservoir plus the Stanislaus River natural flow modification.

The unimpaired flow of the Stanislaus River came from the California Central Valley Unimpaired Flow Data report.

The natural flow modification was developed in two parts. Part 1, the North Fork modification was computed in a 12/3/86 operation study by R. W. Beck and Associates. The study operates New Spicers Meadows reservoir. USBR has incorporated results of the North Fork study into part 2, the South and Middle Forks operation study. The South Fork section of the study operates Strawberry reservoir, Lyons reservoir, and Tuolumne Canal export. The Middle Fork section of the study operates Donnells and Beardsley Reservoirs. The final column in the study is the combined North, Middle, and South Forks modification. USBR provided a copy of the study to DWR 2/17/87.

HISTORIC OUTFLOW: The historic outflow of DA39 is the computed historic inflow to New Melones Reservoir.

10/21 - 9/32	Stanislaus at Knights Ferry minus Melones to Tulloch accretions plus change in storage of Melones and Tulloch reservoirs.
10/32 - 9/57	Stanislaus below Melones Powerhouse plus the change in storage of Melones and Tulloch reservoirs.
10/57 - 9/80	Stanislaus below Goodwin plus historic diversions of Oakdale ID and South San Joaquin ID canals minus accretions from Melones to Goodwin plus change in storage of Melones and Tulloch reservoirs.

81-92 Historic inflow Melones reservoir =
+ Melones releases
+ change in storage

+ evaporation (USBR REPORT OF OPERATIONS)
"see p49.stan" for the calculation"

Stanislaus at Knights Ferry flows were taken from Table 120 of the 1957 Joint Hydrology Study report. Flows of Stanislaus below Melones Powerhouse, flows of Stanislaus river below Goodwin, diversions by Oakdale ID and South San Joaquin ID Canals, and end of month storage for Tulloch and Melones Reservoir. were taken from USGS Water Resources Data reports.

Accretions from Melones to Tulloch were estimated to be 20% of the unimpaired runoff of the Calaveras River at Jenny Lind. Accretions from Tulloch to Goodwin were estimated to be 1.5% of the Calaveras runoff.

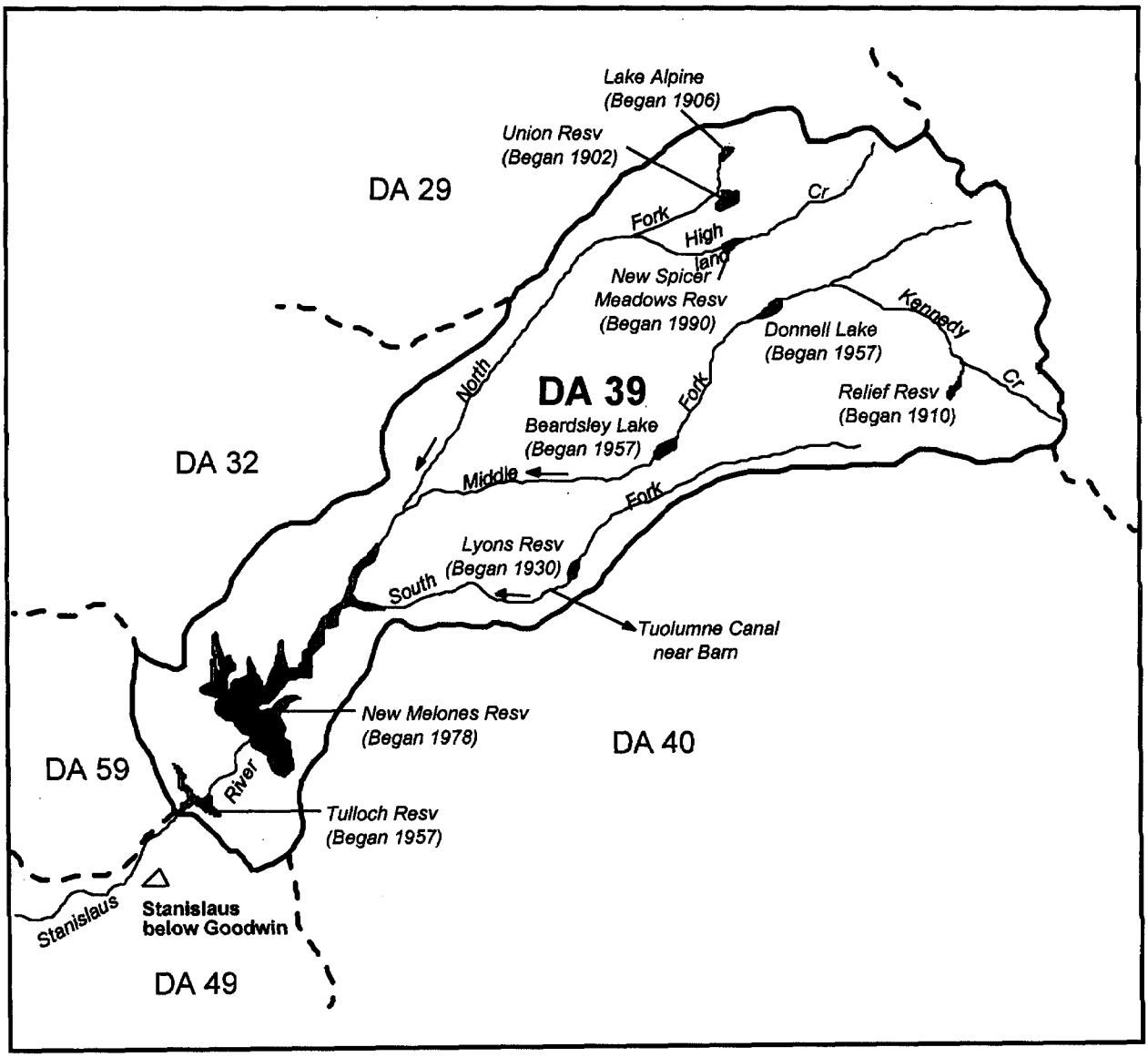


Figure 33: Depletion Area 39 Map

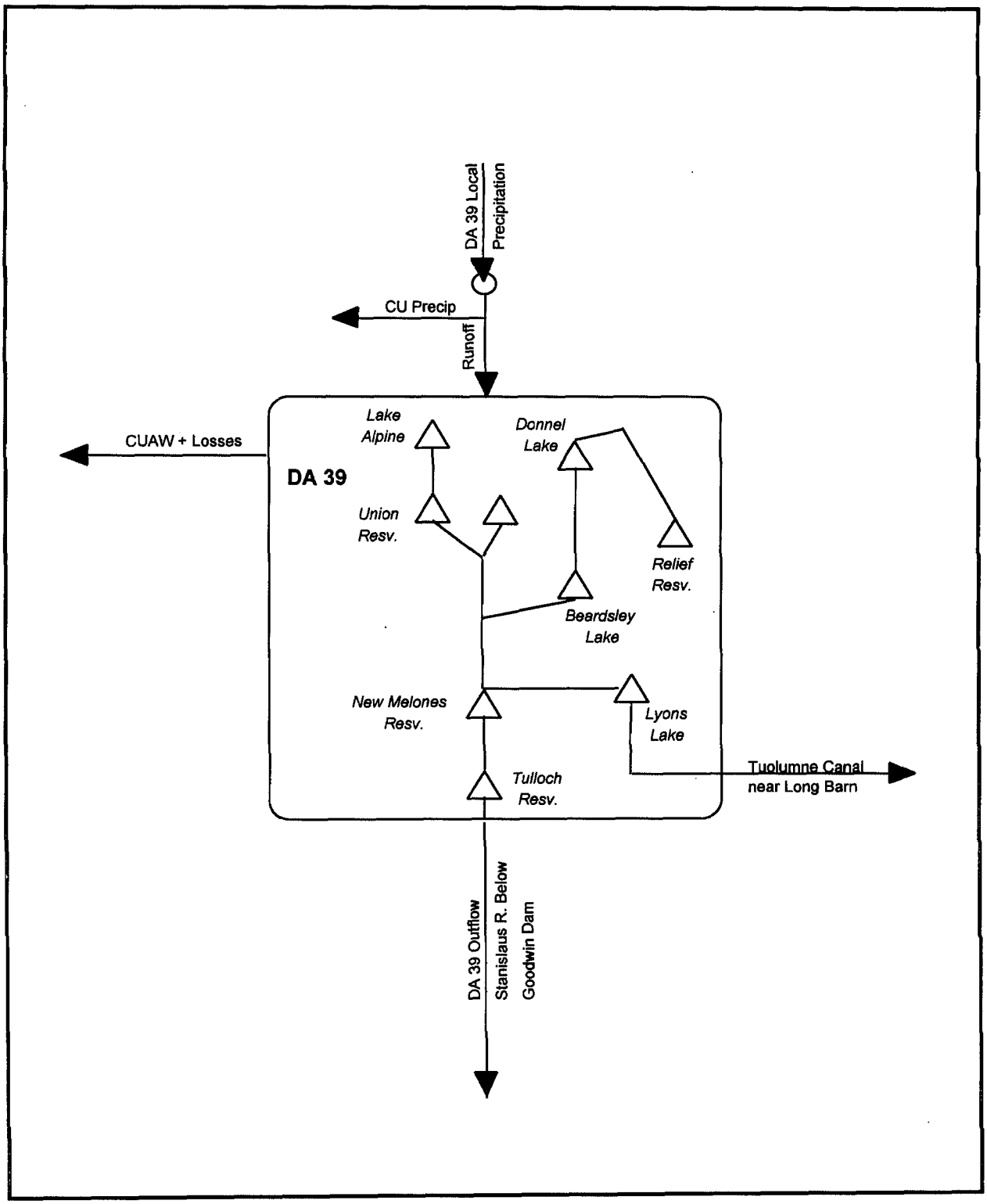


Figure 34: Depletion Area 39 Schematic

DEPLETION AREA 40
TUOLUMNE RIVER

Depletion Area 40 is the drainage area for the Tuolumne River (North Fork, Middle Fork, and South Fork) from New Don Pedro Reservoir to Hetch Hetchy Reservoir. New Don Pedro and Hetch Hetchy are the major reservoirs in DA40.

The exports from DA40 are the diversions of Hetch Hetchy Aqueduct for the City and County of San Francisco.

PROJECTED OUTFLOW: The projected outflow of DA40 was estimated to be the total release of New Don Pedro Reservoir as computed by Bechtel Corporation in July 1965. The study assumed a 295 mgd (330 TAF/year) rate of diversion for Hetch Hetchy Aqueduct and a gross storage capacity of 2,030,000 acre-feet for New Don Pedro Reservoir. The Bechtel study covered the period January 1923 through December 1964. DWR personnel extended the study in December 1975 to include the entire 1922 through 1980 period. Details of the impaired inflow to New Don Pedro are described by Bechtel Corp. in a cover page to a "210 mgd" version of the operation study.

HISTORIC OUTFLOW: The historic outflow of DA40 is calculated as the combined flows of Tuolumne River below La Grange Dam and Modesto and Turlock Canals near La Grange. Monthly flows were taken from USGS Water Resources Data reports.

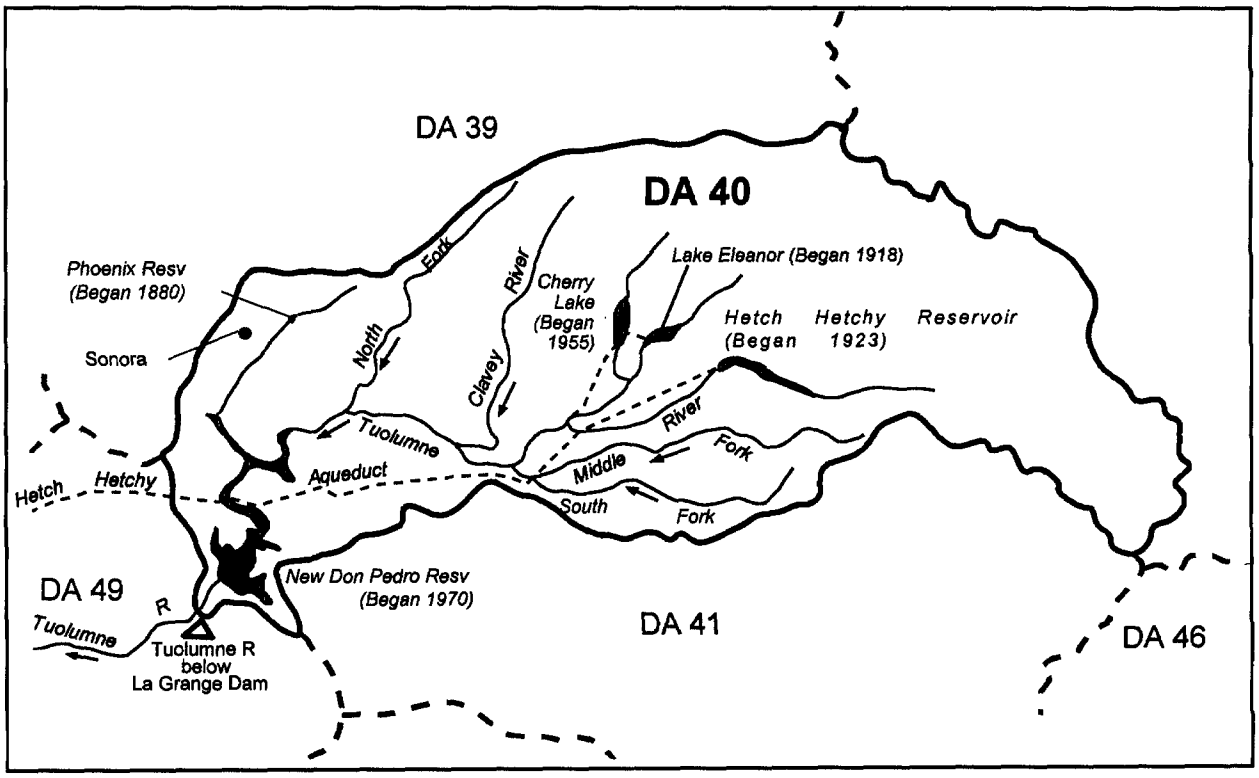


Figure 35: Depletion Area 40 Map

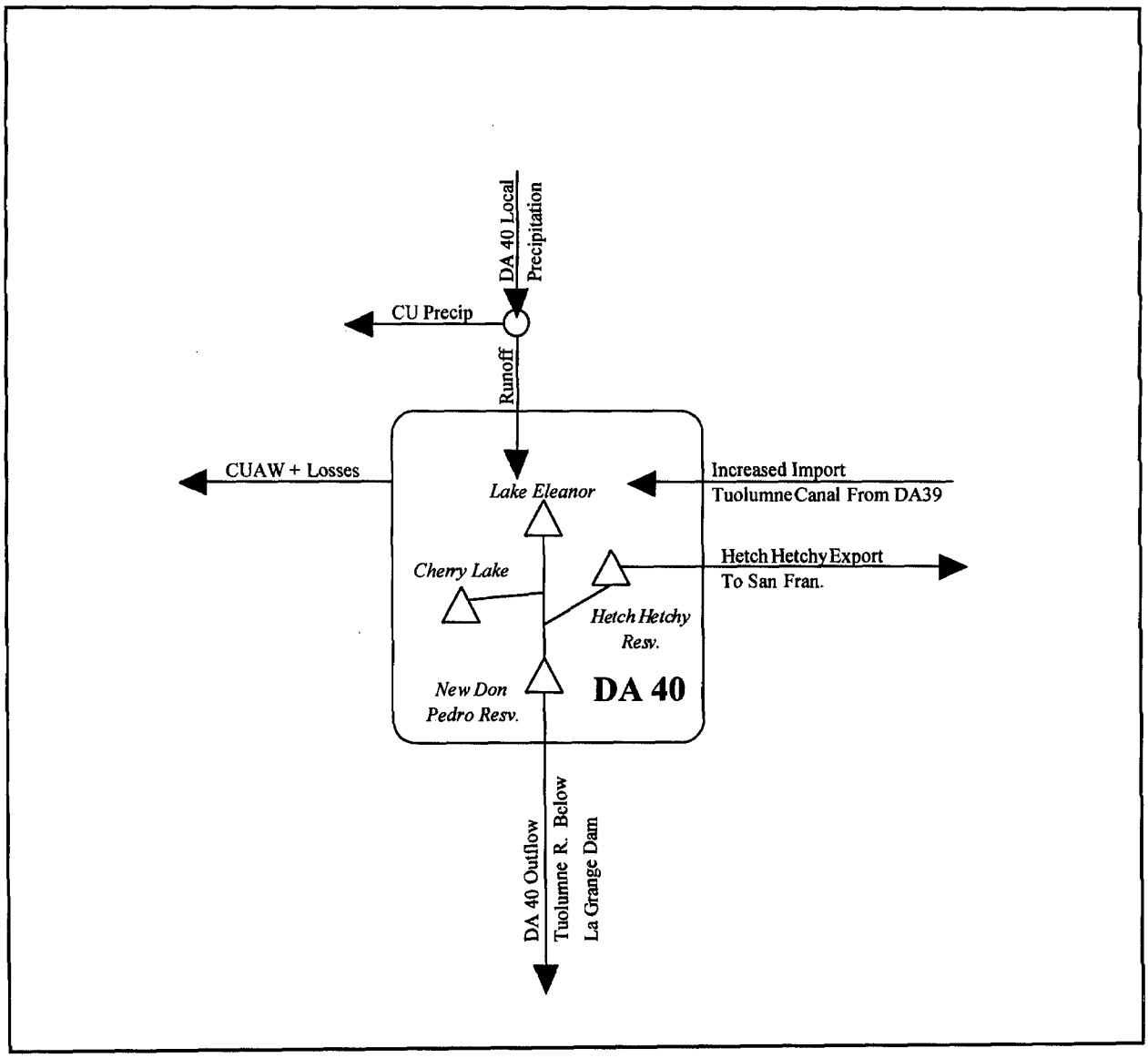


Figure 36: Depletion Area 40 Schematic

DEPLETION AREA 41
MERCED RIVER AT EXCHEQUER

Depletion Area 41 is the drainage area for the Merced River from Lake McClure to its origin in Yosemite Village. DA41 is located on the south side of DA40. Lake McClure is the major reservoir located in DA41.

The Big Creek diversions near Fish Camp are the only export from DA41.

PROJECTED OUTFLOW: Projected outflow is calculated as the sum of discharge and spills as computed by Tudor Engineering in a February 1966 Exchequer Reservoir Operation Study. The study covered the period 1920 through 1946. It was extended to February 1969 by DWR personnel. Beginning March 1969 projected outflow is assumed the same as historic.

HISTORIC OUTFLOW: DA41 historic outflow for the period October 1921 - September 1964 is defined as the flow of the Merced River at Exchequer. Beginning October 1964 historic outflow is calculated as the sum of the Merced River below Merced Falls Dam, near Snelling and Northside Canal diversions. Monthly flows were taken from USGS Water Resources Data reports.

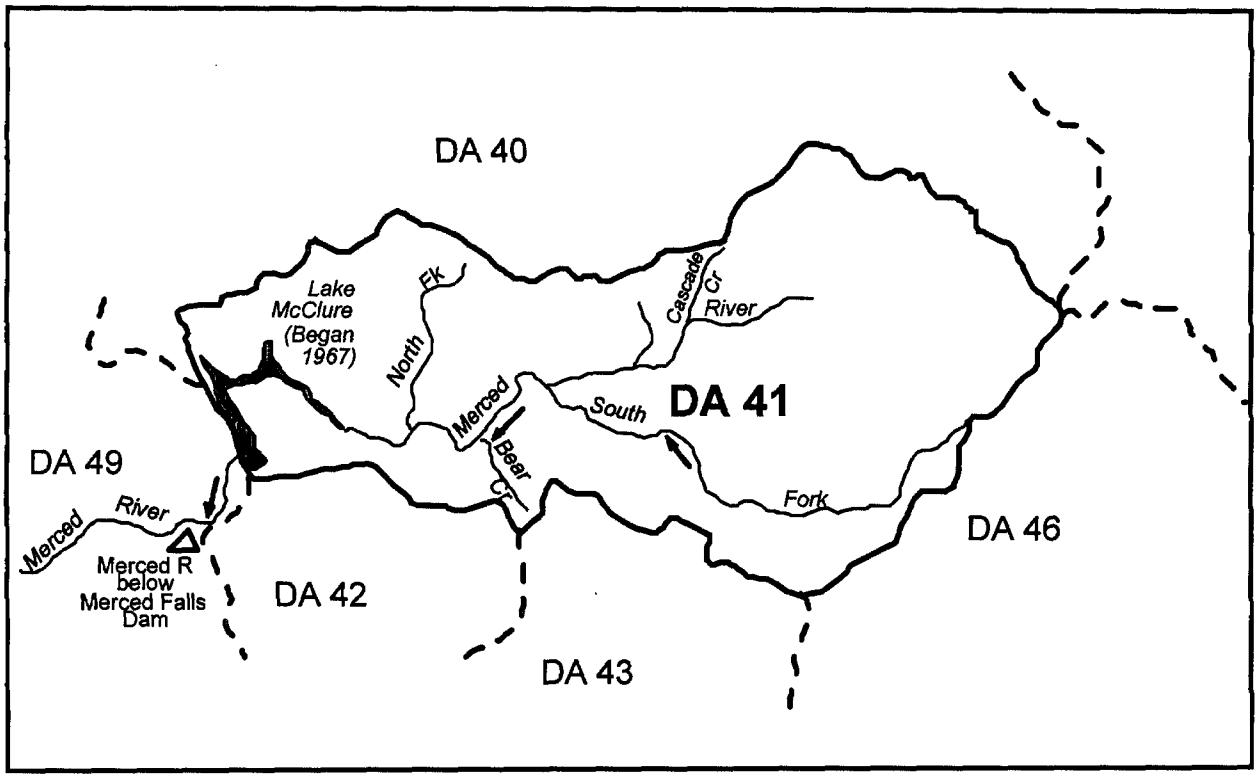


Figure 37: Depletion Area 41 Map

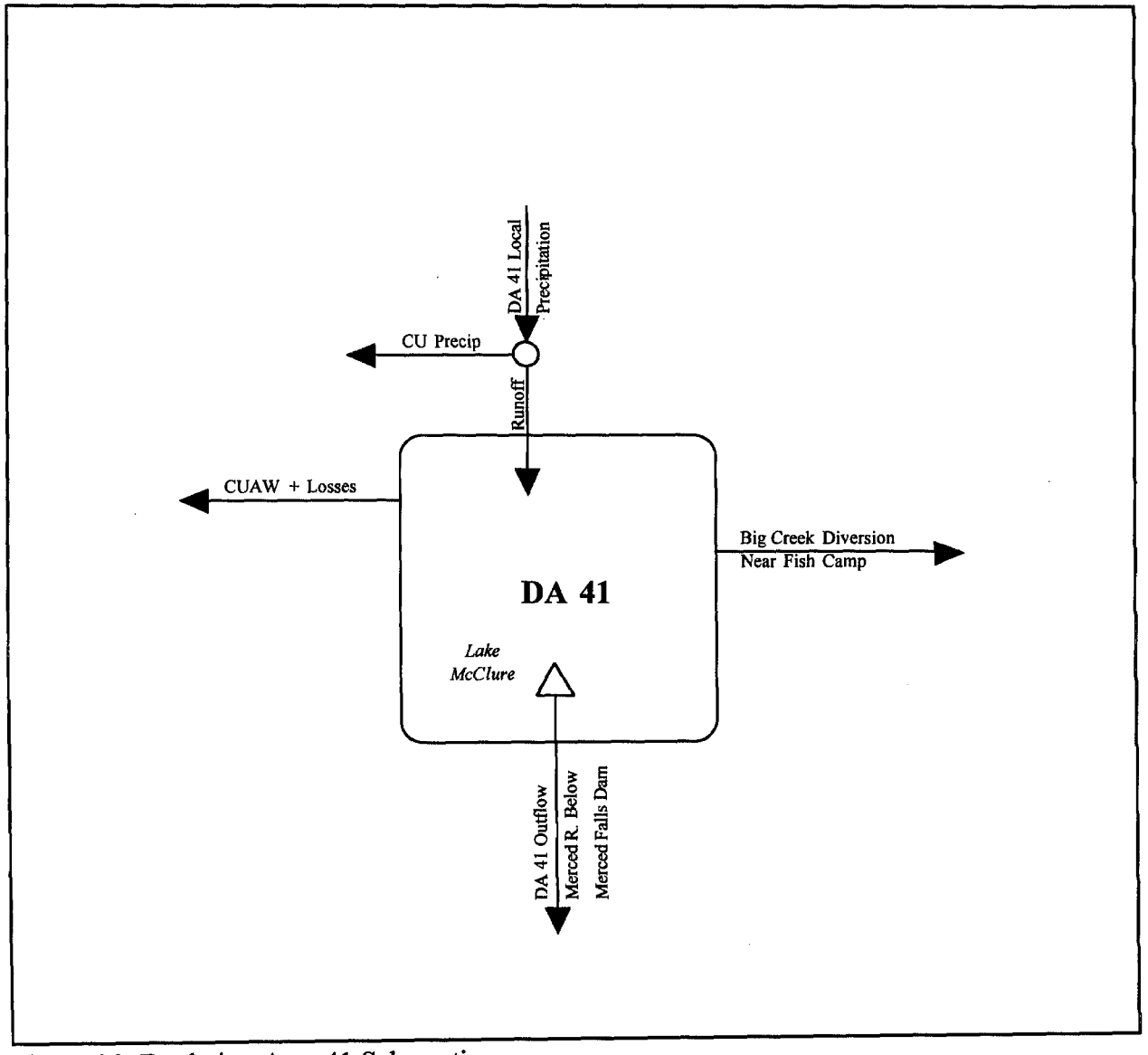


Figure 38: Depletion Area 41 Schematic

DEPLETION AREA 42
BEAR CREEK GROUP

Depletion Area 42 is the drainage area for several minor creeks including the Bear Creek and Mariposa Creek. DA42 is located on the east side of DA49.

PROJECTED OUTFLOW: Projected outflow was assumed the same as historic.

HISTORIC OUTFLOW: DA42 historic outflow is calculated as the sum of Mariposa, Owens, Bear, and Burns Creeks below their respective dams plus an estimate of unmeasured runoff for the remaining area. The flows in the four creeks were published in DWR Water Supervision reports beginning January 1955. Flows of Mariposa, Owens, and Burns Creeks for the months of October, November, and December 1954 were obtained from US Army Corps of Engineers records. Flows in Bear Creek for the period October 1954 through February 1955 were estimated from partial records and comparison with other creeks.

Prior to water year 1955, historic flows of the four creeks were derived from annual runoff estimates in a DWR memorandum "Historical Inflow to San Joaquin Valley from Merced County" by J. M. Mathison, dated March 11, 1960. Annual outflow for DA42 was computed by summing runoff of the four creeks and 48% of unmeasured flow computed by Matheson. Monthly distribution is the same as that of Chowchilla River at Buchanan Damsite.

Beginning October 1957, runoff of the unmeasured area was estimated as 1.86 times the flow of Bear Creek near Cathay. Beginning October 1969, Bear Creek near Cathay was estimated by correlation with Mariposa Creek near Cathay. Mariposa Creek near Cathay was taken from USGS Water Resources Data reports. Beginning water year 1961, USGS has renamed the Bear and Mariposa gages as "...near Catheys Valley".

WY-1981/92 Historic outflow Bear Creek Group is determined by linear correlation with Chowchilla River inflow to Eastman lake.

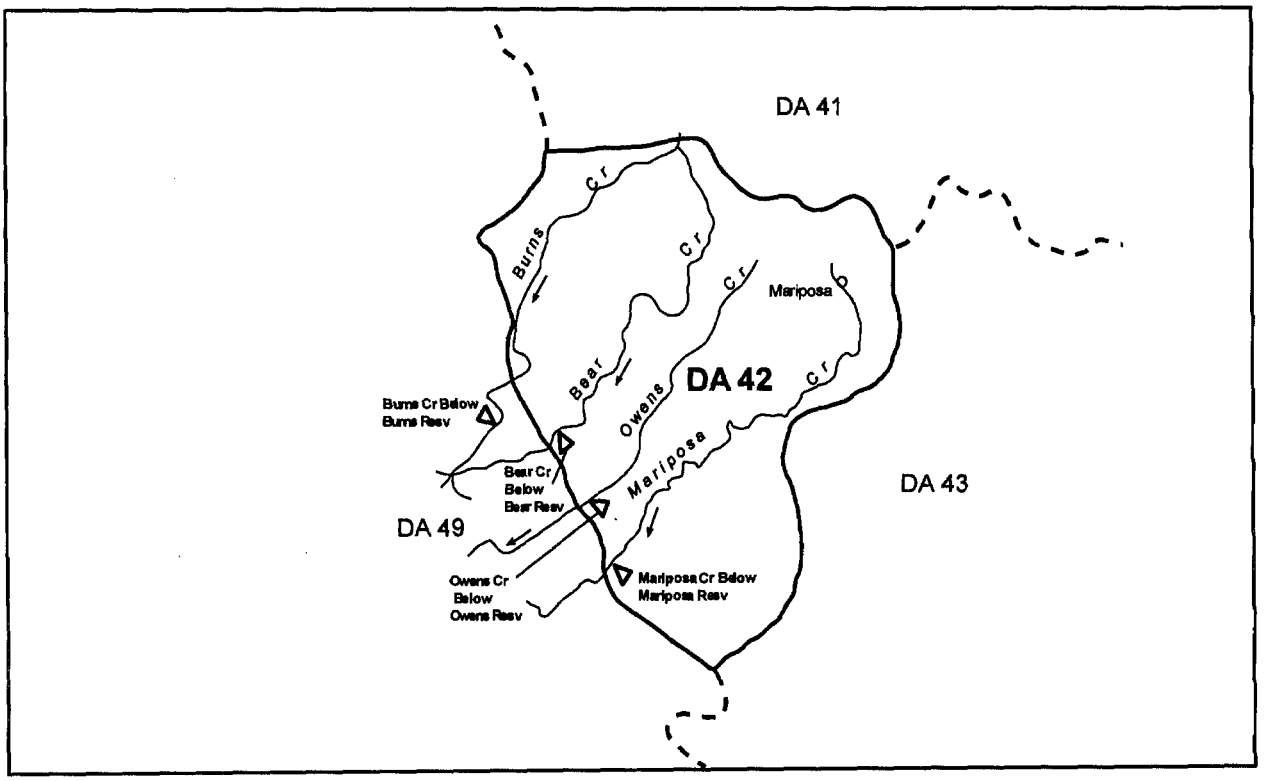


Figure 39: Depletion Area 42 Map

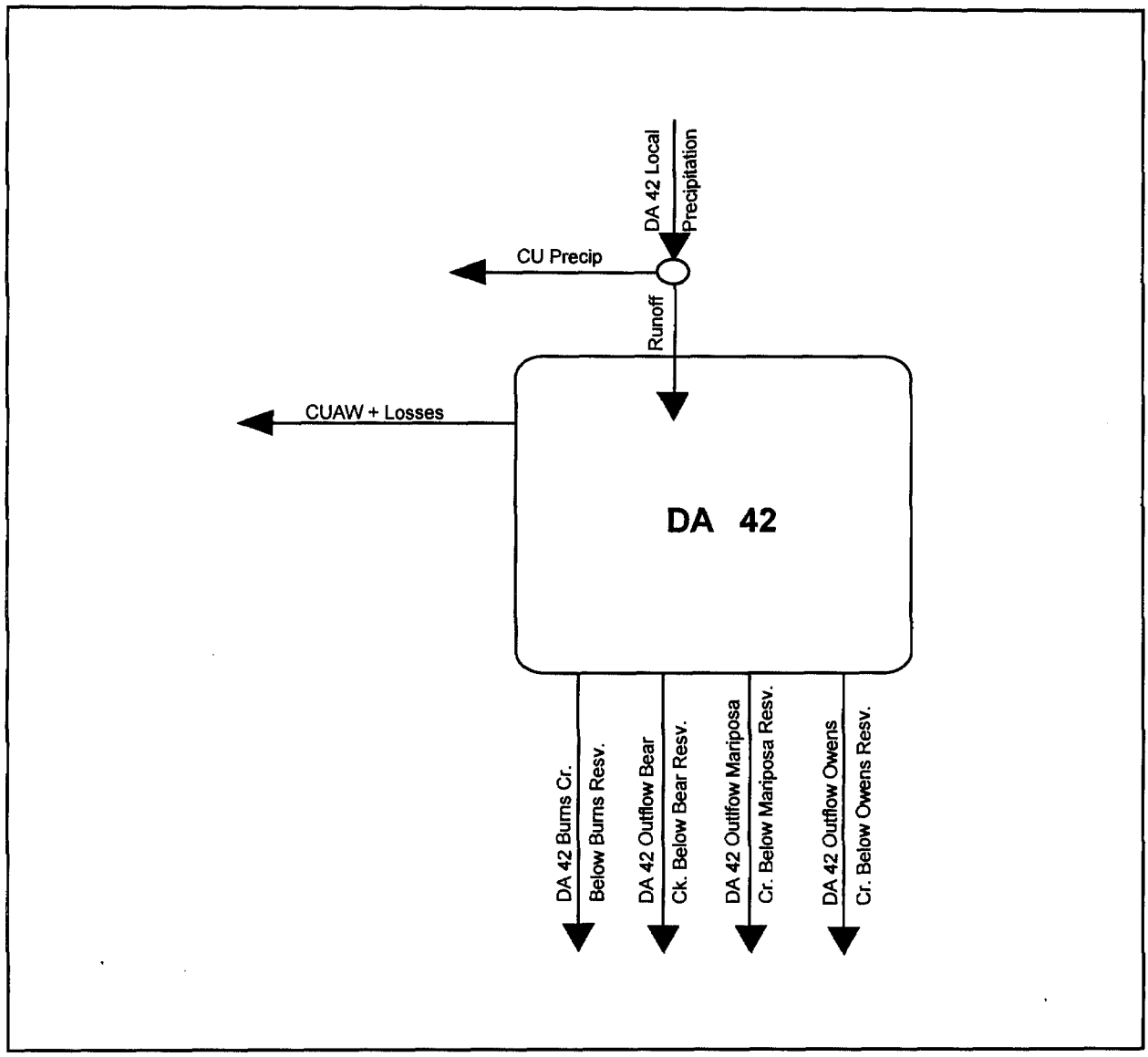


Figure 40: Depletion Area 42 Schematic

DEPLETION AREA 43
CHOWCHILLA RIVER BELOW BUCHANAN RESERVOIR (EASTMAN LAKE)

Depletion Area 43 is the drainage area for the Chowchilla River from its origin to just below Eastman Lake. It is located on the east side of DA42 and south side of DA41. Eastman Lake is the major reservoir in DA43.

PROJECTED OUTFLOW: The projected outflow of DA43 is calculated as the historic outflow plus basin modification of Buchanan Reservoir

HISTORIC OUTFLOW: Historic outflow of DA43 is calculated 1.025 times the estimated and measured run off of Chowchilla River at Buchanan damsite. The gage has been relocated several times as summarized below:

10/21-9/23. Chowchilla River at Buchanan dam site, USGS.
10/23-9/30. Estimated by US Army Corps of Engineers.
10/30-9/62. Chowchilla River at Buchanan dam site, USGS.
10/62-9/72. Chowchilla River at Buchanan damsite, near Raymond, USGS.
10/72-9/75. Chowchilla River below Raynor Creek, near Raymond, USGS.
10/75-9/91. Chowchilla River below Buchanan Dam, near Raymond, USGS.

BASIN MODIFICATION: Modification is calculated as the change in storage minus evaporation for Buchanan Reservoir as computed 10/22/59 by USBR in an R-4 routing operation study. The study covers the period January 1914 - December 1958. The study was extended by USBR to September 1972 and further extended by DWR to March 1978. Beginning May 1978, historic Buchanan Reservoir was assumed to be at full operation.

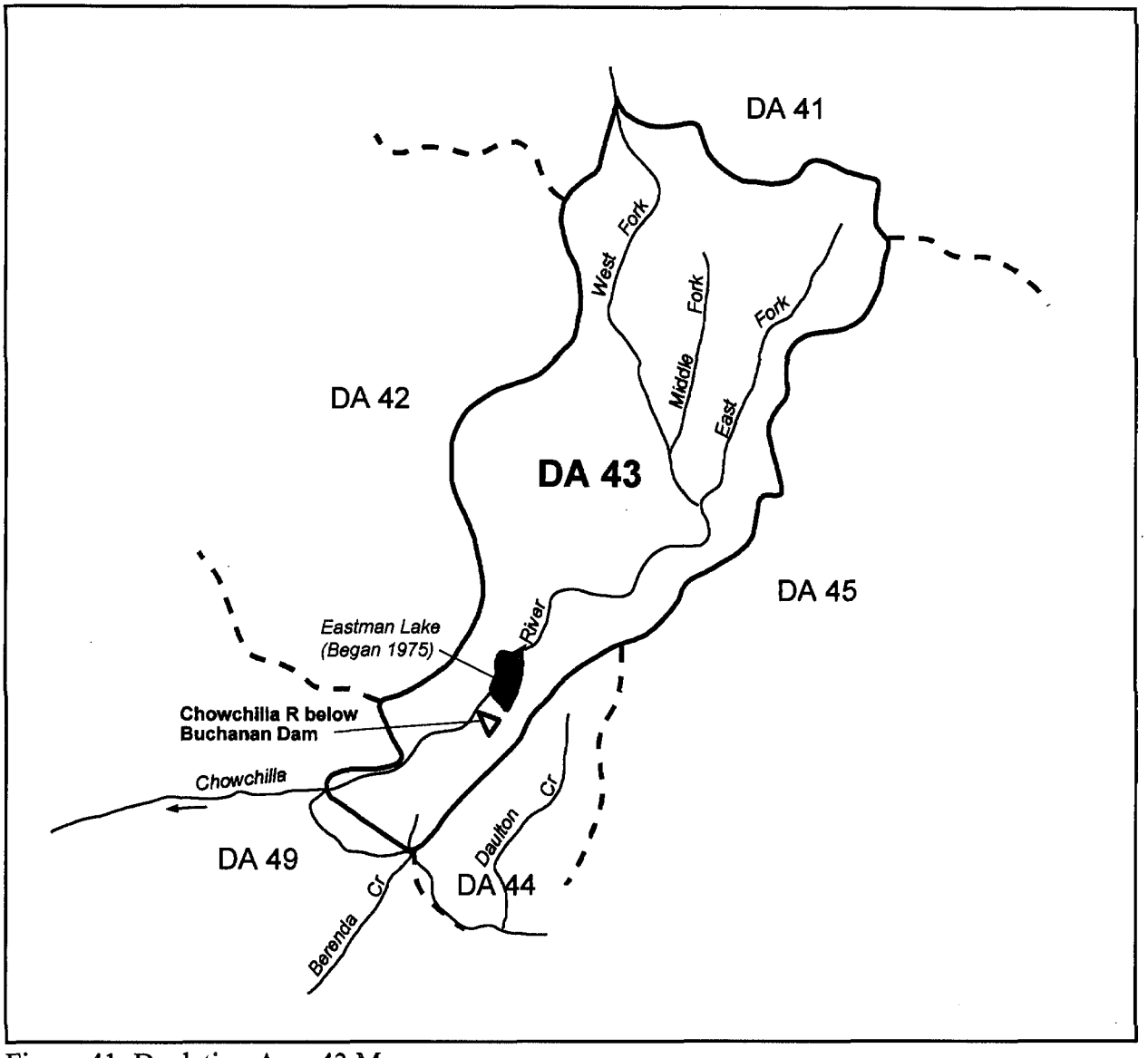


Figure 41: Depletion Area 43 Map

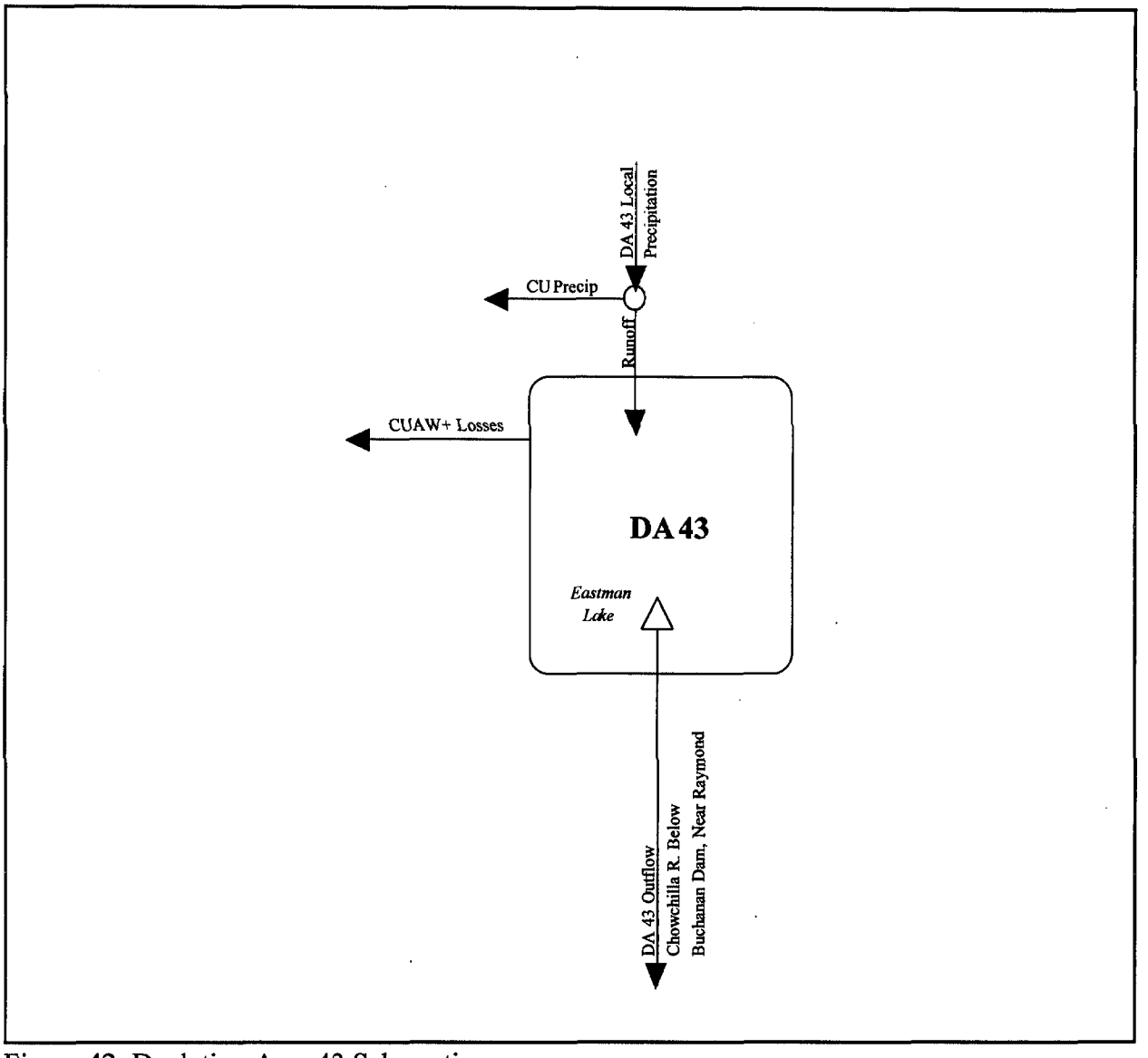


Figure 42: Depletion Area 43 Schematic

DEPLETION AREA 44
BERENDA CREEK

Depletion Area 44 is the drainage area for a small segment of Daulton Creek. DA41 is bounded on the northwest by DA43 and DA45 on the northeast.

PROJECTED OUTFLOW: Projected outflow was assumed the same as historic.

HISTORIC OUTFLOW: Historic outflow was estimated for the entire period by correlation with the local runoff of various creeks.

10/21 - 9/41	By correlation with Fresno River near Knowles.
10/41 - 9/51	1.4 times Cottonwood Creek near Friant.
10/51 - 9/57	0.53 times Little Dry Creek near Friant.
10/57 - 9/66	1.76 times Striped Rock Creek near Raymond.
10/66 - 9/91	By correlation with Chowchilla River at Buchanan Damsite, adjusted for change in storage and evaporation of Eastman Lake.

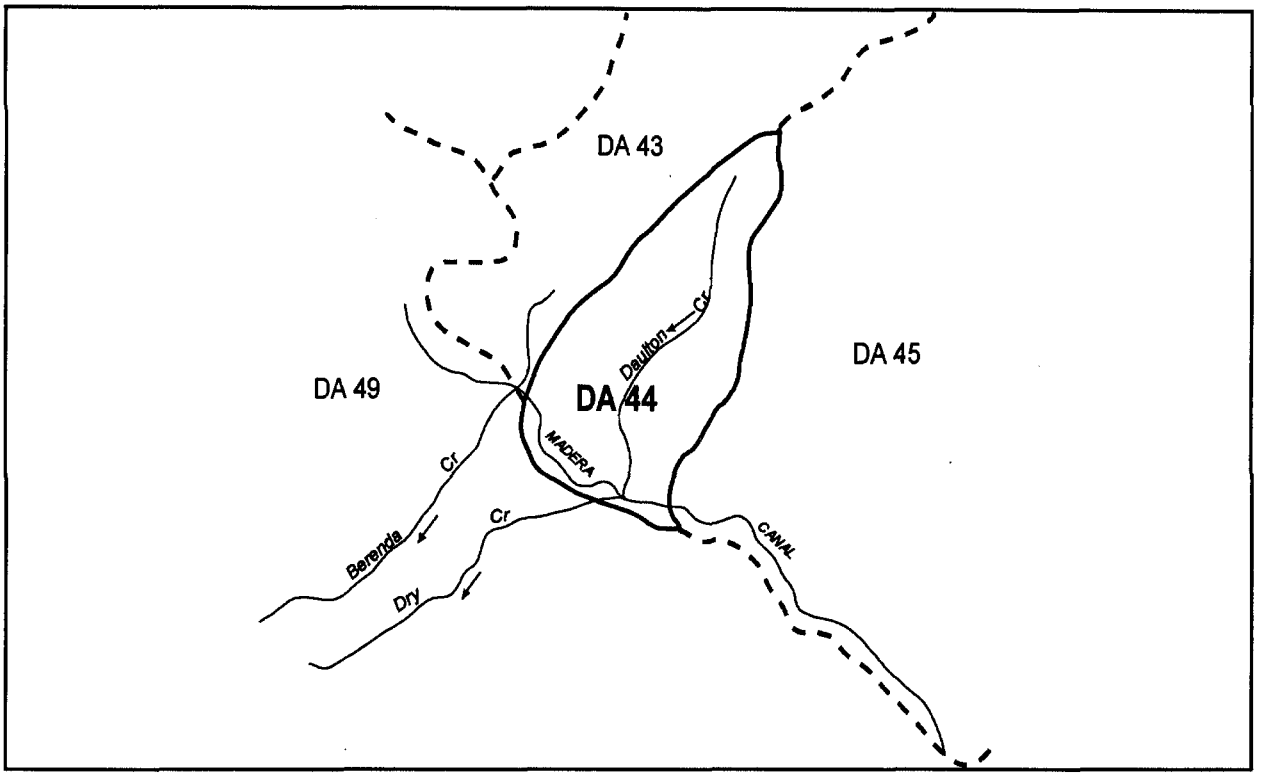


Figure 43: Depletion Area 44 Map

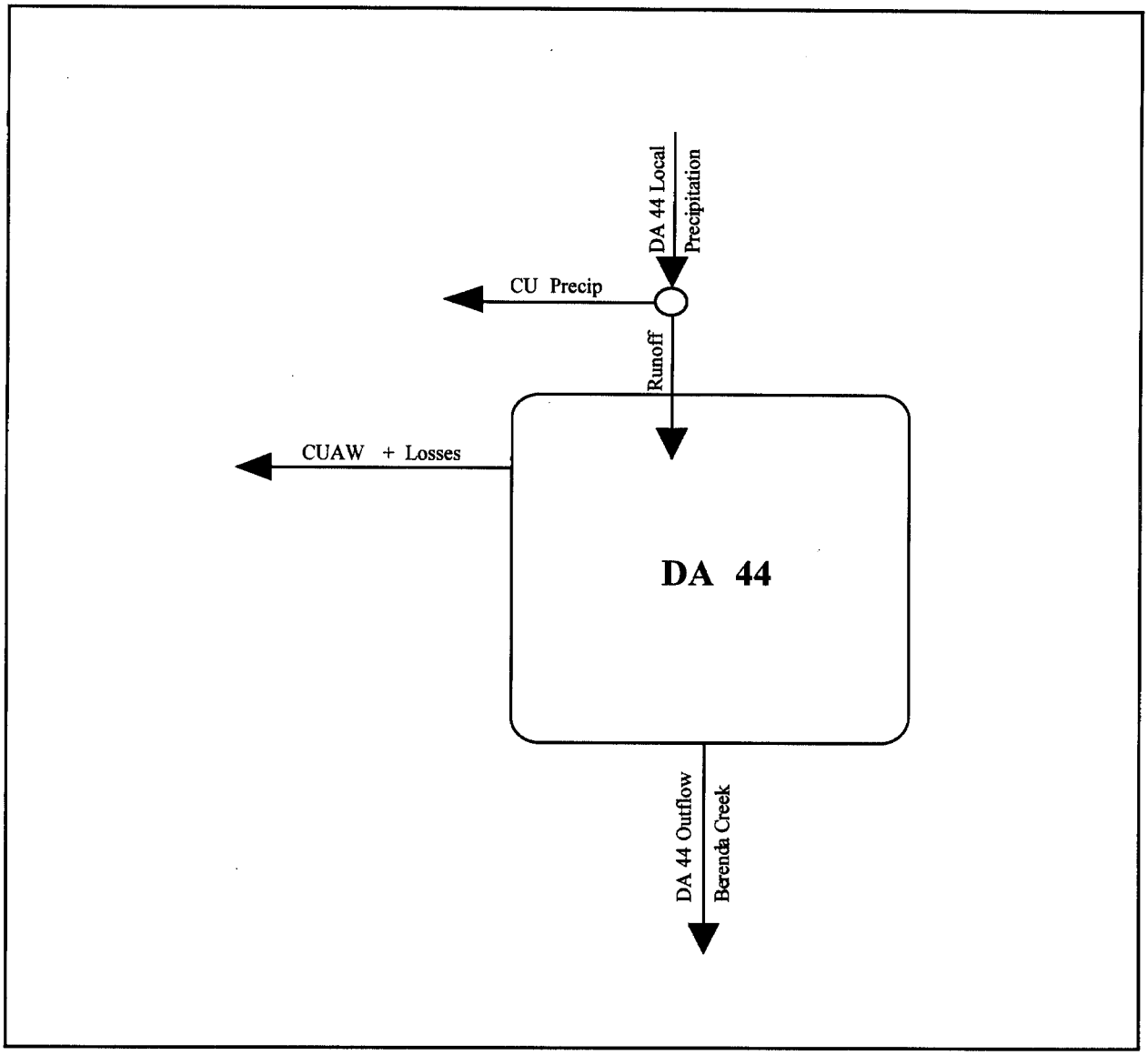


Figure 44: Depletion Area 44 Schematic

DEPLETION AREA 45
FRESNO RIVER

Depletion Area 45 is the drainage area for Fresno River from its northern-most point to just above Madera Lake. DA45 is located on the east side of DA43 and DA44.

HISTORIC OUTFLOW: Historic outflow of DA45 is defined as the estimated and measured runoff of Fresno River near Daulton. For the period October 1921 - September 1941, Fresno River near Daulton flows were estimated by correlation with Fresno River near Knowles. Beginning October 1975, the unadjusted flow of Fresno River below Hidden Dam, near Daulton was used.

PROJECTED OUTFLOW: Projected outflow of DA45 is defined as the total releases as shown in the US Army Corps of Engineers' Hidden Reservoir Operation Study R-1, dated March 1959. The original operation study covered the period January 1922 - December 1951. The study was extended to September 1971 by USBR and to June 1978 by DWR. Beginning July 1978 Hidden Reservoir was assumed to be at full operation and the projected outflow is the same as the historic.

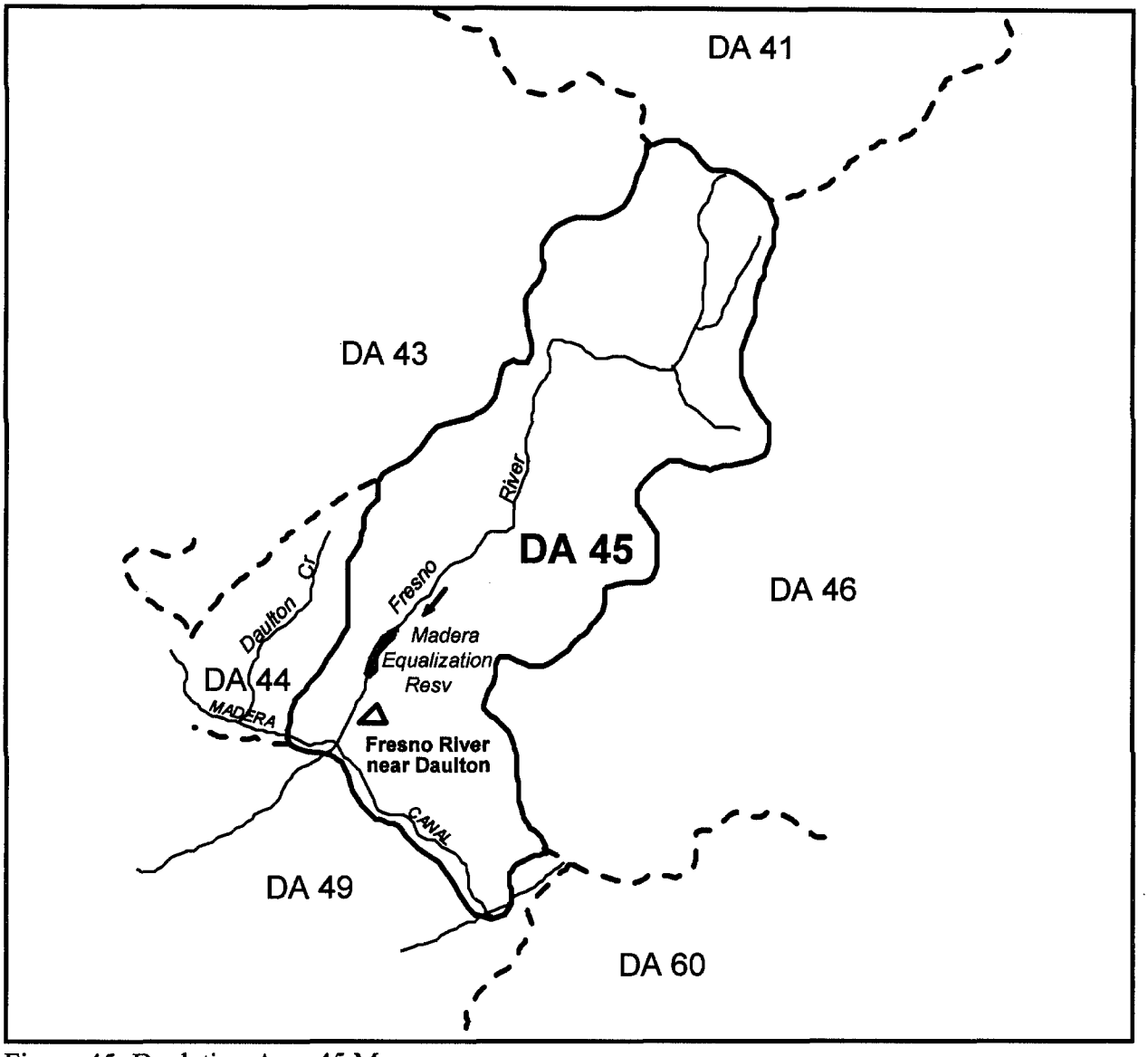


Figure 45: Depletion Area 45 Map

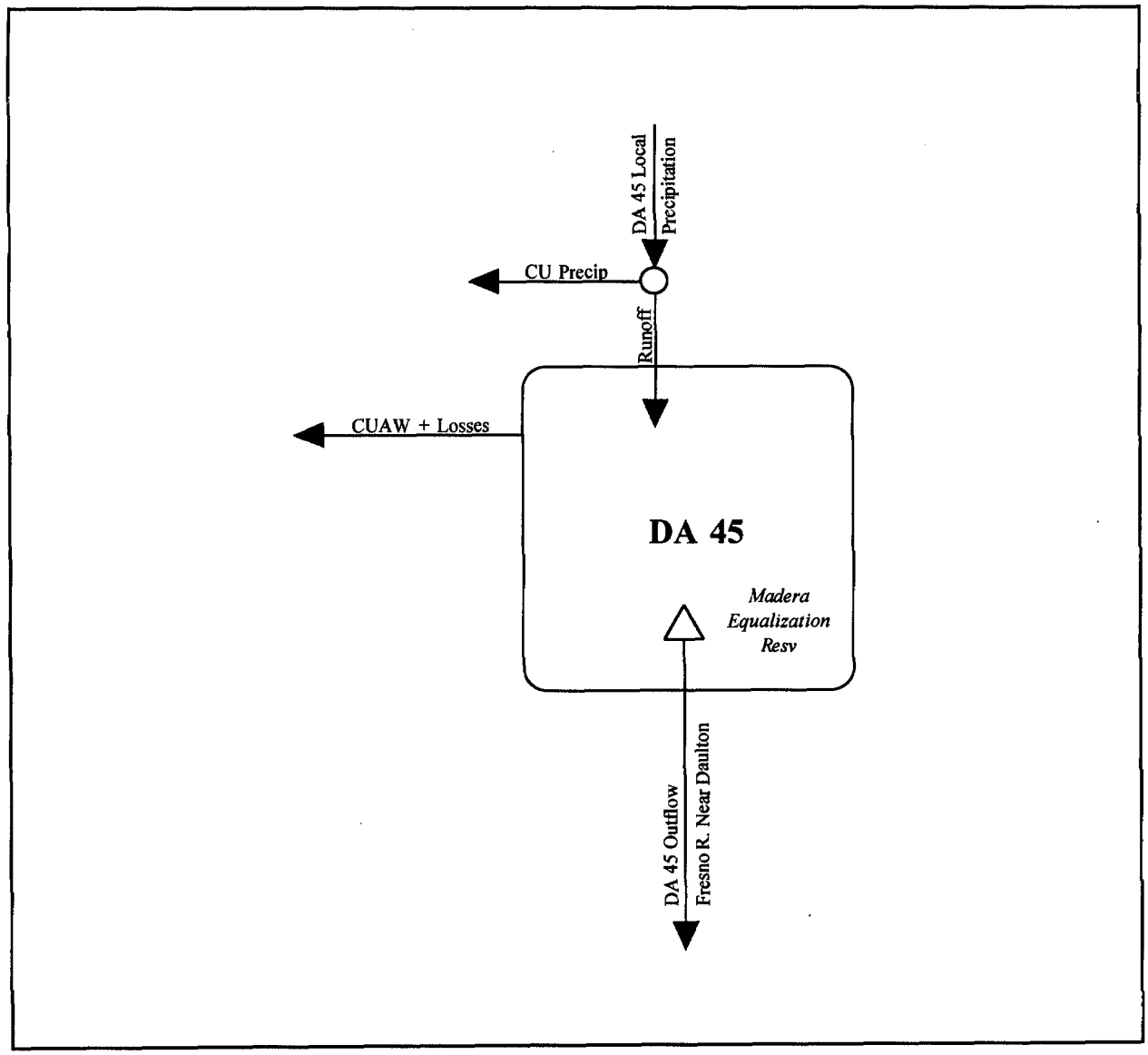


Figure 46: Depletion Area 45 Schematic

DEPLETION AREA 46
SAN JOAQUIN RIVER BELOW FRIANT

Depletion Area 46 is the drainage area for the segment of the San Joaquin River above Friant. Millerton Lake is the major reservoir in DA46.

The exports from DA46 are the sum of Madera Canal, Friant-Kern Canal, and Soquel Ditch.

PROJECTED OUTFLOW: The projected outflow of DA46 was computed from data taken from the Millerton Lake Operation Study 13B, developed by the US Bureau of Reclamation. Projected outflow equals total project releases plus river releases to downstream riparian diverters minus Madera and Friant-Kern Class 1 and Class 2 water minus Fresno City water minus losses.

HISTORIC OUTFLOW: Historic outflow of DA46 is defined as the flows of the San Joaquin River below Friant, as published in the USGS Water Resources Data reports. The flows are those left in the river after Madera and Friant-Kern Canal diversions

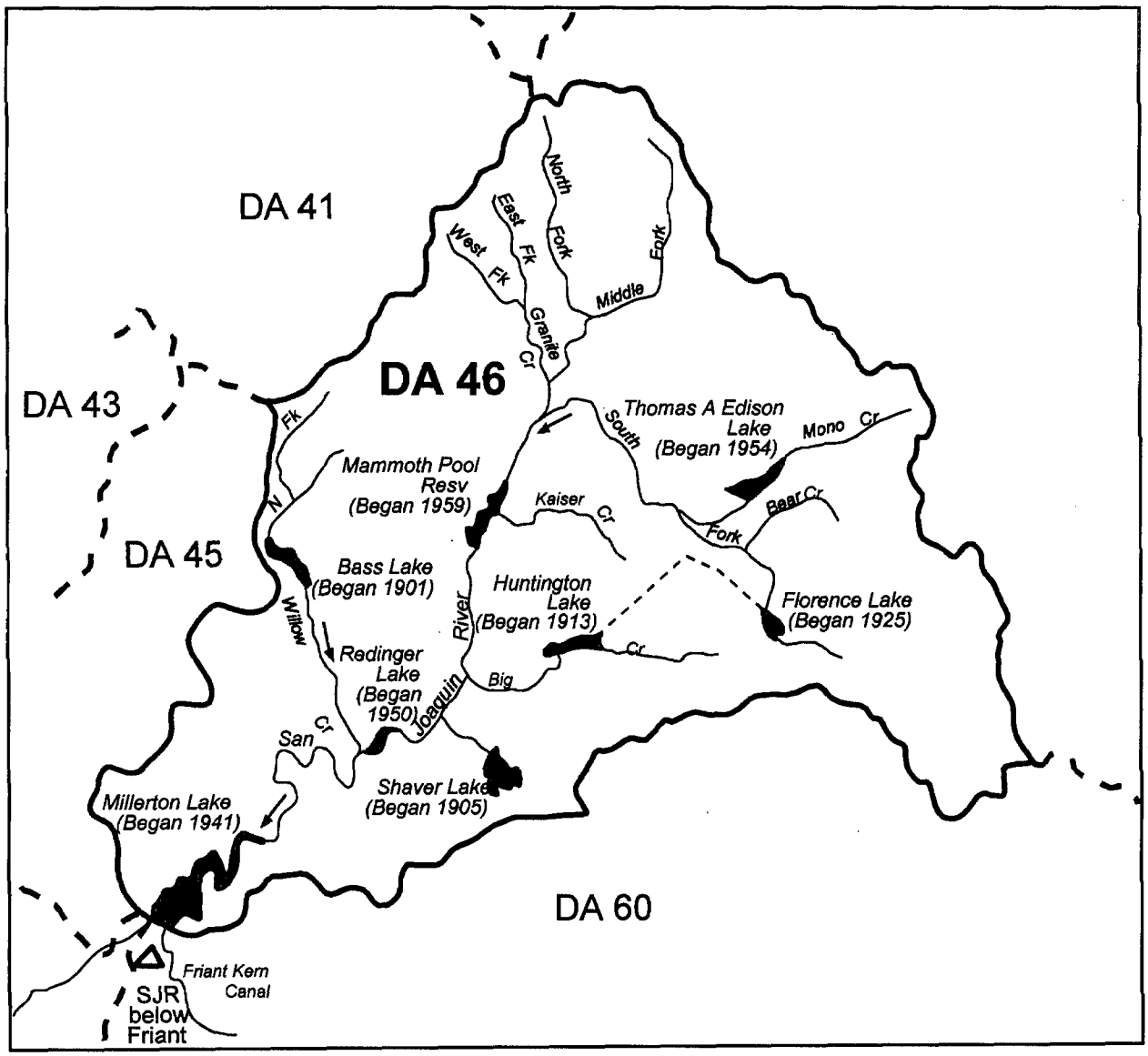


Figure 47: Depletion Area 46 Map

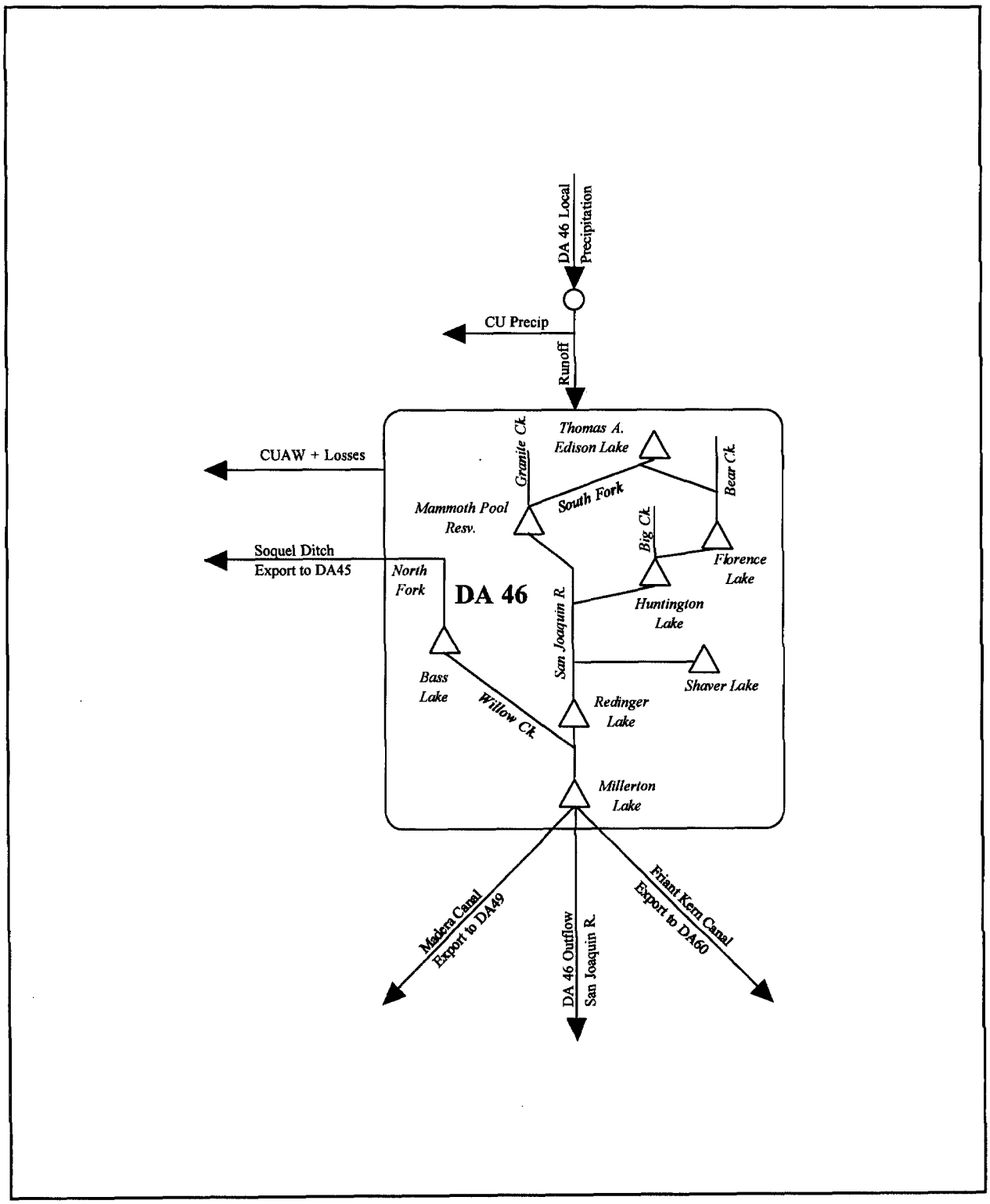


Figure 48: Depletion Area 46 Schematic

DEPLETION AREA 49
SAN JOAQUIN RIVER NEAR VERNALIS

Depletion Area 49 covers the lower San Joaquin River below Millerton Reservoir to the Vernalis gage. The area includes the Merced River below Exchequer Reservoir (Lake McClure), the Tuolumne River below New Don Pedro Reservoir, and the Stanislaus River below New Melones Reservoir and the minor tributaries from the west side of the San Joaquin River between Mendota Pool and Vernalis.

The exports from DA49 include Fresno Slough diversions (from Mendota pool) plus the diversions on the south bank of the San Joaquin River from Friant to Fresno Slough.

PROJECTED OUTFLOW: The projected outflow of DA49 is calculated as:

+ Historic outflow
+ Historic export
- Projected export
+ Increased imports
+ Basin modifications
+ Upstream modification, DA's 39 - 46
+ Historic depletion
- Projected depletion
+ Projected additional groundwater pumping
- Projected additional groundwater recharge

HISTORIC OUTFLOW: Historic outflow of Depletion Area 49 is the San Joaquin River near Vernalis. Monthly data was taken from USGS Water Resources Data reports. Missing data occurring between 1921 and 1930 was taken from Table 114 of the 1957 Joint Hydrology Study report.

HISTORIC EXPORT: Historic export from DA49 to the Tulare Basin equals historic diversions from the left bank of the San Joaquin River from Mendota Dam (mile 209) to Friant Dam (mile 268) plus historic diversions from Fresno Slough and Fresno Slough Bypass.

10/21 - 9/46 Left bank diversions were estimated to be 7 TAF/year based on 1947-54 average. Fresno Slough diversions were based on James ID and Tranquility ID diversions reported in DWR Bulletin No. 21, "Irrigation Districts in California". Annual totals for the combined left bank and Fresno Slough diversions were distributed on the 1947-54 average monthly export pattern.

10/46 - 9/75	Export equals San Joaquin River left bank diversions from Fresno Slough to Friant Dam plus total diversions from Fresno Slough and Fresno Bypass. The diversions were taken from DWR Water Supervision Reports. Two left bank diverters above Mendota Dam, namely, Central California I.D. and Firebaugh Canal Co. are not included in the export because they are located within the DA49. Beginning October 1970, left bank diversions between Gravelly Ford and Friant Dam were estimated to be 6 TAF/year.
10/75 - 9/78	Export data was obtained from USBR monthly Reports of Operation.
10/78 - 9/91	Export was estimated by USBR. Diversions between Mendota Dam and Gravely Ford were taken from USBR monthly Reports of Operations. Diversions between Gravely Ford and Friant Dam were estimated to be 10.5 TAF/year.

PROJECTED EXPORT: DA49 projected San Joaquin River export to Tulare Basin is based on recent year historic left bank and Fresno Slough diversions.

10/21 - 9/64	Normal year export equals the average 1970-1980 export of 134 TAF. Deficient year export equals the historic export for calendar year 1977. Deficient years are 1931 and 1977. Deficient years are indicated when the unimpaired inflow to Millerton Reservoir is less than 500 TAF and the previous year inflow is below normal (1740 TAF).
10/64 - 9/91	Projected export equals the historic export.

INCREASED IMPORTS: Increased imports include Madera Canal from DA46, Kings River overflow into Fresno Slough, Delta Mendota Canal and Federal San Luis Canal from the Delta.

Projected Madera Canal import was estimated from USBR Millerton Reservoir Operation Study No. 13B. The import equals 1.03 times Madera Canal Class 1 and Class 2 water. Beginning October 1971 projected import was assumed to be the same as historic. Historic Madera Canal import data was taken from USGS Water Resources Data reports.

Kings River overflow into Fresno Slough equals projected spills from Pine Flat Reservoir, limited to 5000 cfs, minus historic spills of the Kings River into the San Joaquin River. Projected spills were taken from a Kings River Water Conservation District operation study of "Existing" Pine Flat Reservoir. The operation study labels the spills as "Excess Irrigation Releases". Beginning Ocotber 1971, projected import was assumed to be the same as historic.

Historic Kings River overflow was developed as follows:

10/21 - 3/27 Kings River near Burrel minus Beta Main and James Main Canals. Data was taken from DWR Bulletin 38, Kings River Water Association Water Master report, 1931.

4/27 - 9/65 Kings River in Fresno Slough plus Kings River in Fresno Slough Bypass. Data through September 1931 were taken from DWR Bulletin 38. Beginning October 1931, data was obtained from the Kings River Water Association table dated Ocotber 1965.

10/65 - 9/91 Kings River at James Bypass. Data was taken from USBR Monthly Reports of Operations listed in the Streamflow, Sacramento - San Joaquin Valleys table. Data was converted to TAF/month from mean monthly flow in CFS.

Projected Delta-Mendota Canal import for the period October 1921- September 1969 is defined as 1609 TAF/year less deficiency in critical year 1934. The import was further reduced for local supply from Millerton Reservoir spills and Kings River overflow into Fresno Slough. Beginning October 1969 projected import was assumed to be the same as historic. The projected DMC demand of 1609 TAF/year was provided to us by USBR. In order to estimate the local supply, the Exchange contract portion needed to be identified. Based on earlier USBR data the following breakdown was developed.

	Normal Year	25% Deficient Year
DMC Agriculture and State of Calif.	561	451
Grasslands	50	25
Schedule II	38	30
Canal Losses	120	98
Exchange Contract	840	680
Total	1609	1284

Local supply from Millerton and Kings River is available to the Exchange Contract portion of the DMC import. Millerton spills were taken from USBR Operation Study 13B. Millerton spills available to DMC users were limited to 1500 cfs. Kings River overflow into Fresno Slough are described above.

Historic DMC equals Delta Mendota Canal at Tracy Pumping Plant less delivery to South Bay

aqueduct less pumped plus generation water at O'Neill forebay. Historic DMC began operating June 1951. Monthly data was taken from USGS Water Resources Data reports. Deliveries to South Bay Aqueduct from DMC occurred during the period June 1962 - November 1967. Monthly data was taken from DWR Water Supervision report table called "Deliveries from Central Valley Project Canals". Pumped and generation water at O'Neill is listed in USBR Reports of Operations under "Consolidated State-Federal O'NEILL Forebay Daily Operations".

Projected Federal San Luis Canal imports are those deliveries made from the California Aqueduct to water districts located in DA49. Districts receiving significant amounts of water are Panoche WD, Pacheco WD, and San Luis WD. According to USBR, annual amounts contracted by these districts are San Luis WD, 79 TAF; Panoche WD, 44 TAF; and Pacheco WD, 9 TAF totaling 132 TAF. Historic deliveries listed in USBR Reports of Operations indicate that 1990 level import is closer to 160 TAF/year. Projected DA49 import for Federal San Luis Canal was, therefore, set at 160 TAF in a normal year with 25% deficiencies in critical years 1934 and 1977. Historic imports began March 1968. Historic imports were taken from USBR Monthly Reports of Operations. They are listed under "San Luis and Cross Valley Canals, Monthly Deliveries in Acre-feet".

BASIN MODIFICATION: Basin modifications include historic groundwater overdraft adjustment, adjustment to remove the effects of New Melones and Tulloch Reservoirs, and project water from New Melones Reservoir.

Historic ground water overdraft adjustment is included in order to fully identify shortages in surface and ground water supplies needed to meet projected demands. The adjustment, in effect, increases the diversion from theoretical storage during months of short supply and decreases the projected outflow of DA49 during months of surplus supply. Prior to 1939 ground water storage remained at a constant levels indicating no ground water overdraft. During the 1955-66 period ground water storage levels declined an average of 130 TAF/year. Overdraft was, therefore, estimated to increase steadily from zero in 1938 to 130 TAF/year in 1955 and remaining at 130 TAF/year through 1966. Around 1970, the DWR San Joaquin District Office made an analysis of the San Joaquin River basin and estimated that the ground overdraft in 1967 was about 170 TAF. Overdraft adjustment was ,therefore, increased from 130 TAF in 1966 to 170 TAF in 1967. Based on a 1972 estimate of 250 TAF, presented in DWR Bulletin 160-74, overdraft was increased to 250 TAF by 1972. Based on supporting data to DWR Bulletin 160-83 the overdraft adjustment was allowed to level off at 246 TAF by the year 1980.

Adjustment to remove the effects of Melones and Tulloch Reservoirs equals the historic change in storage for the two reservoirs. Evaporation was neglected. Old Melones began storing August 1926, capacity 110 TAF. New Melones dam was completed November 1978, capacity 2420 TAF. Tulloch reservoir began storing November 1957, capacity 68 TAF.

Project water is that portion of Oakdale, South San Joaquin ID, and lower Stanislaus river demands not met by projected inflow to New Melones Reservoir nor accretions below Melones.

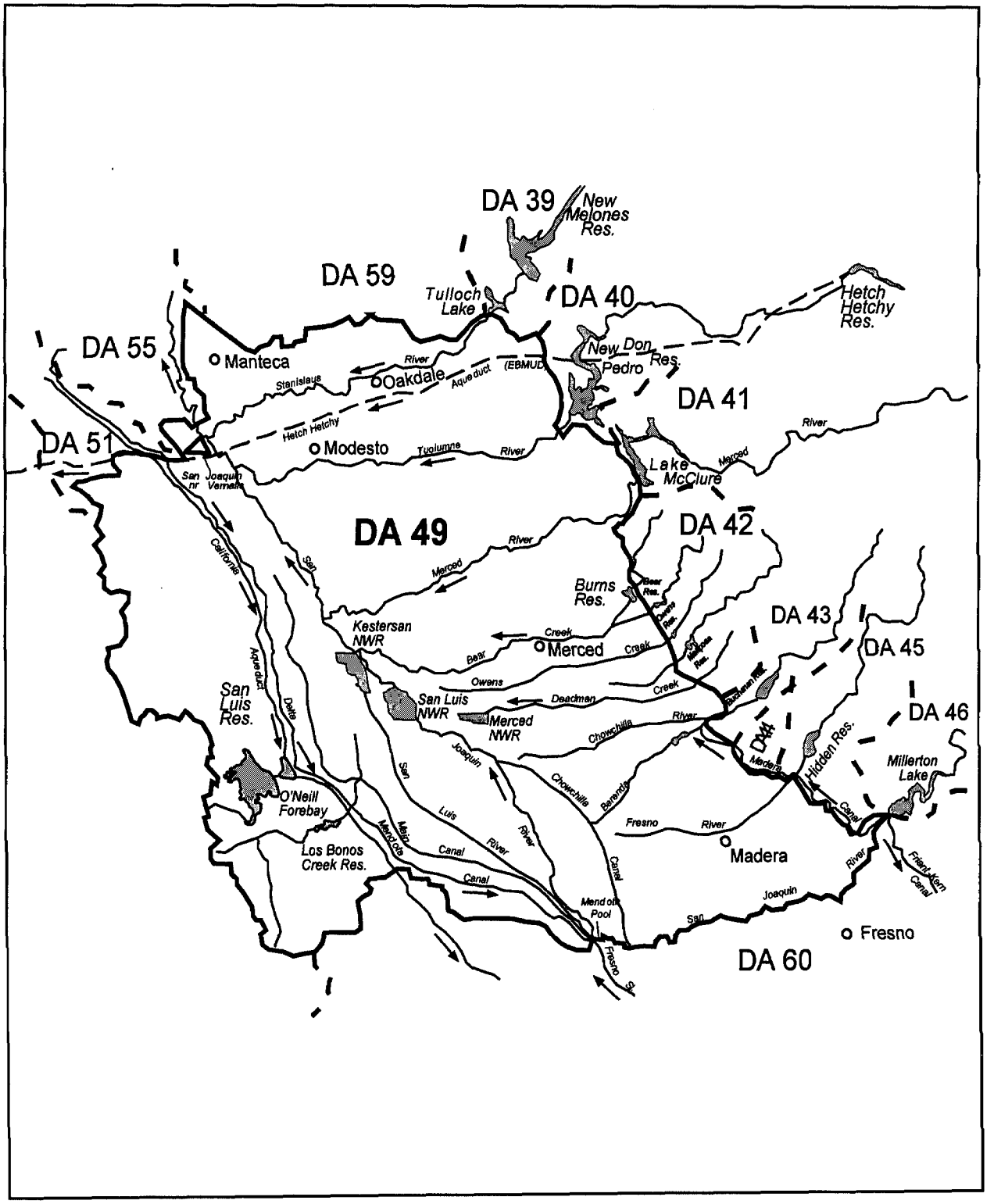


Figure 49: Depletion Area 49 Map

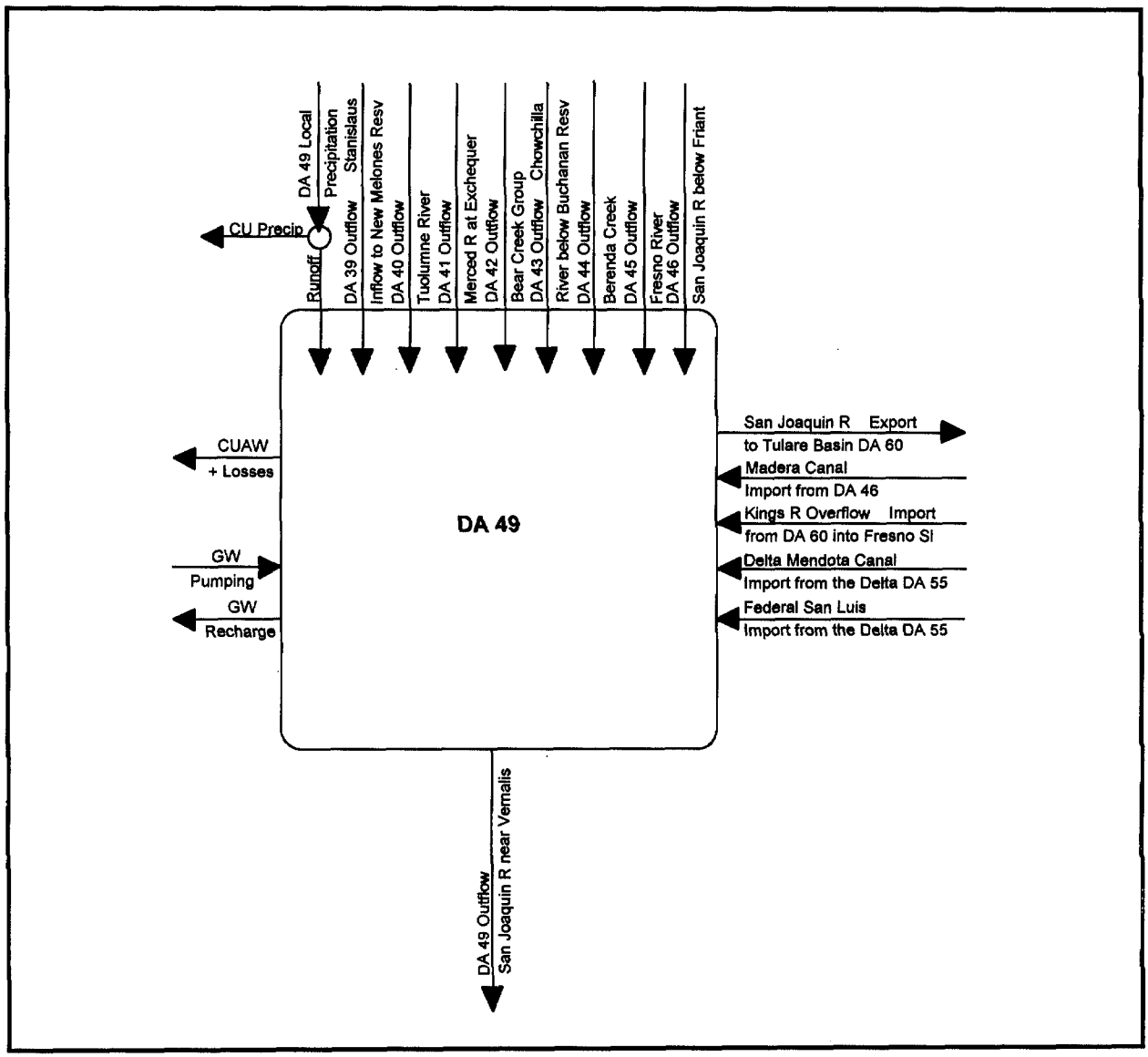


Figure 50: Depletion Area 49 Schematic

DEPLETION AREA 51
MARSH CREEK

Depletion Area 51 is located along the south west corner of the Delta Service Area. It includes many minor creeks which flow toward the border of the Delta. According to old assumptions made in the middle 1960's, Marsh Creek contains the only runoff from all these creeks that would reach the delta. The total area of DA51 is 359 sq. miles. The drainage area of Marsh Creek is 42 sq. miles. The old Aug 22,1977 memo report on Input data for 1980 and 2000 level Central Valley Depletion Studies says that except in extremely wet months, flows from these unmeasured creeks is negligible.

The depletion analysis begins with an historic outflow that is essentially zero during the irrigation season and ends up simulating a projected outflow of 1 TAF (thousand acre-feet) per month.

Marsh Creek water and the historic depletion is not enough water to fully supply the irrigated land use at present or future levels. The depletion analysis program usually computes additional ground water pumping and recharge to meet any shortages in diversion requirement. In DA51 such shortages are assumed to be met from additional surface water imports. The Aug. 22, 1977 memo report indicates that most of these additional imports would probably come from the Delta-Mendota and Contra Costa Canals.

PROJECTED OUTFLOW: The projected outflow of DA51 is equal to:

+ Historic outflow
+ Additional Import
+ Historic depletion
- Projected depletion

HISTORIC OUTFLOW: Historic outflow of DA51 equals the gaged flow of Marsh Creek near Byron.

10/21 - 9/54	Marsh Creek flows were estimated by correlation with Calaveras River at Jenny Lind..
10/54 - 9/91	The Marsh Creek flows were taken from USGS Water Resources Data reports.

BASIN MODIFICATION: Basin modification is defined as additional import needed to meet

increased water demands in DA51. The additional import is calculated from the diversion from theoretical storage generated by running a depletion study of DA51 without an import.

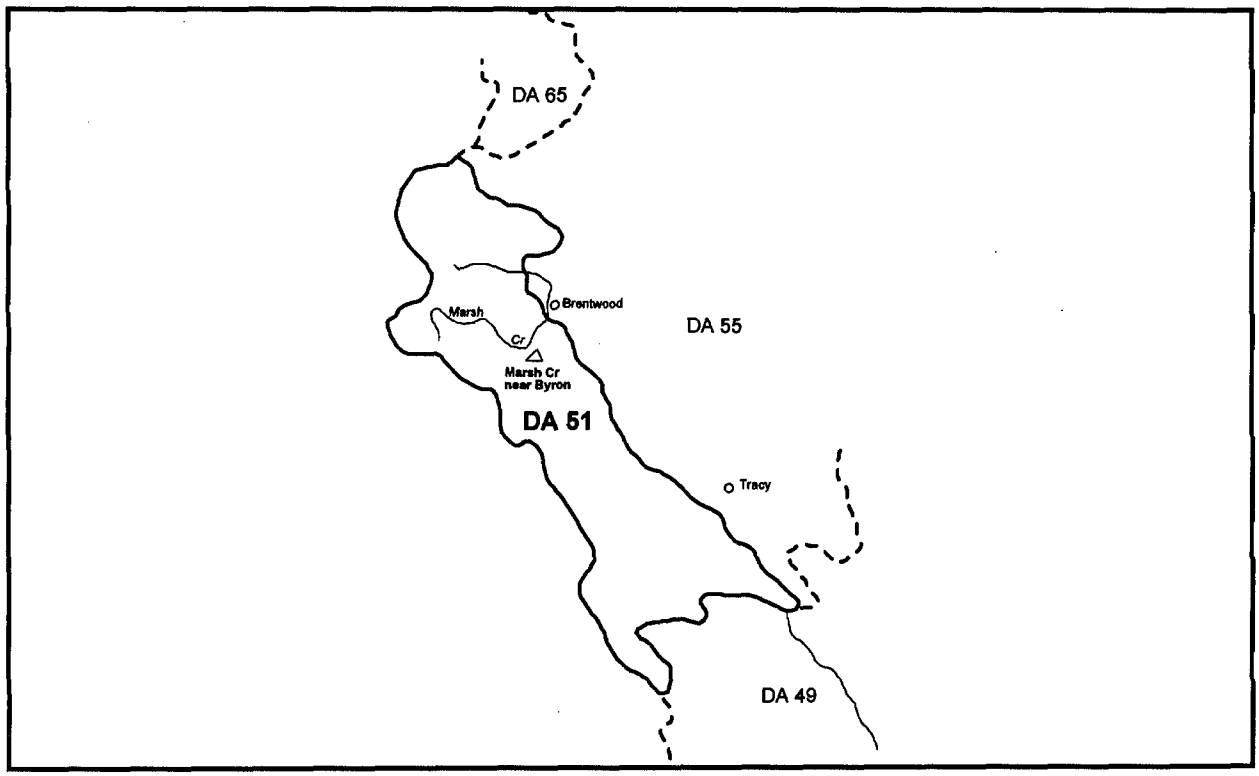


Figure 51: Depletion Area 51 Map

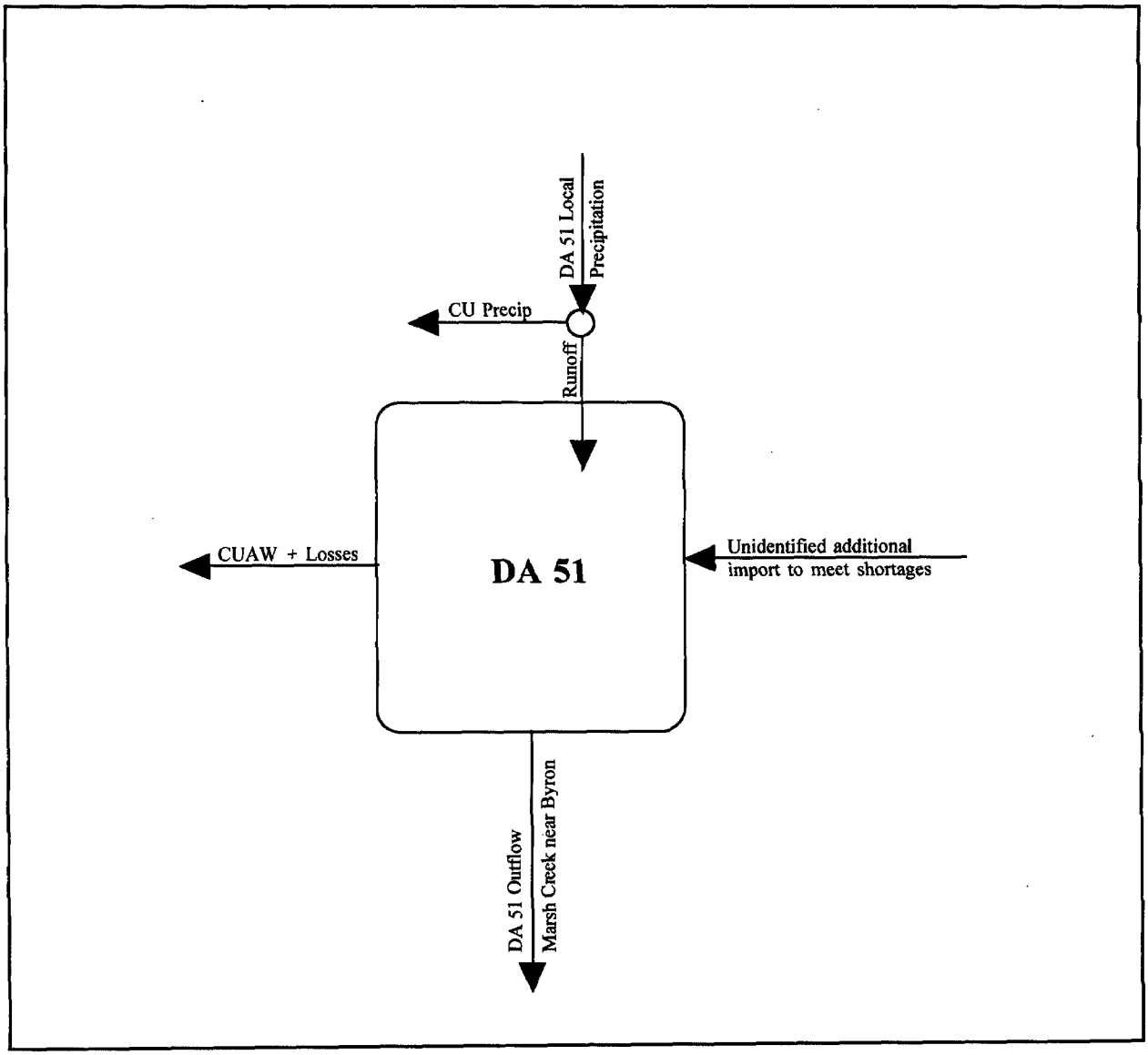


Figure 52: Depletion Area 51 Schematic

DEPLETION AREA 55
DELTA SERVICE AREA

A depletion analysis is not run for this area. Only a consumptive use model is run to determine the total basin precipitation and the total delta consumptive use.

To model the consumptive use in the delta, the delta service area is divided into two sub-areas called 'uplands' and 'lowlands'. The lowlands are generally those lands below 5 feet in elevation. The lowlands include all of the levied islands. The uplands include a portion of the Yolo Bypass, Brentwood/Tracy area, and western portion of the city of Stockton. Uplands and Lowlands are described in greater detail in an old office memo report called 'Documentation of Delta Joint Hydrology Meetings, Aug. 8, 1966'.

In 1981 George Sato from DWR Central District, Norman Macgillivray from DWR San Joaquin District, and Gordon Lyford from USBR Environmental Section reworked the evapotranspiration and leach water data for the delta. Evapotranspiration and leach water data currently used in our consumptive use model is described in detail in an office memo called 'Joint DWR and WPRS Delta Channel Depletion Analysis, April 1, 1981. Soil moisture and seepage criteria was developed by Maurice Roos and Art DeRutte in the middle 1970's and is described in a Dec. 19, 1976 memo, called 'Results of the Computed Change in Delta Soil Moisture Studies'.

Delta Water Requirements for DWRSIM Models is computed for Projected Levels of land use. The most recent land use projections are based on DWR Bulletin 160-93 data. The projections are from the Central District. They are by county/DAU. DAU means Detailed Analysis Units, a set of sub-areas for the entire state. The delta service area consists of two DAU's, 185 for the southern delta and 186 for the northern delta. The projected land use is not broken into Uplands and Lowlands areas, but prorations based on surveyed data enabled us to make the breakdown.

For DWRSIM models the projected delta water requirements for both uplands and lowlands becomes a yearly diversion at Control Point 54 (YD54). Total precipitation for both uplands and lowlands becomes the local inflow at Control Point 54 (IN54).

Several delta models rely on historic delta water requirements. Historic land use needed to compute historic delta water requirements was developed and refined by John Kono, Land and Water Use Analyst in the Central District, in June 1985. The land use covered the period 1922 thru 1980. The 1981 thru 1992 period was extended from survey data.

DEFINITION OF DELTA WATER REQUIREMENTS AND 'NET USE':

Delta water Requirements = delta lowlands total consumptive use

+leach water storage regulation
+soil moisture storage regulation
+ delta uplands total consumptive use

Delta net use = delta water requirements
- delta lowlands total precipitation
- delta uplands total precipitation

Leach water storage regulation equals to the change in monthly storage due to the flooding of islands for the purpose reducing the salts in the soil.

The following is abstracted from G. Sato, Land and Water Use Analyst, Central District April 1, 1981 Delta Channel Depletion Analysis Report:

Month	Average Land Areas Flooded at the End of the Month (1000 acres)	Change in Land Areas Flooded	Monthly Change in Storage* (1000 acre-feet)
Sep	0	0	0
Oct	5.6	+5.6	+11.2
Nov	13.6	+8.0	+16.0
Dec	26.8	+13.0	+26.4
Jan	11.8	-15.0	-30.0
Feb	4.0	-7.8	-15.6
Mar	0	-3.7	-7.4
Apr	0	-0.3	-0.6
May	0	0	0
Jun	0	0	0
Jul	0	0	0
Aug	0	0	0
Sep	0	0	0

(*) Volume storage assumes one foot of water ponded plus one foot of stored in the soil for a total depth of two feet.

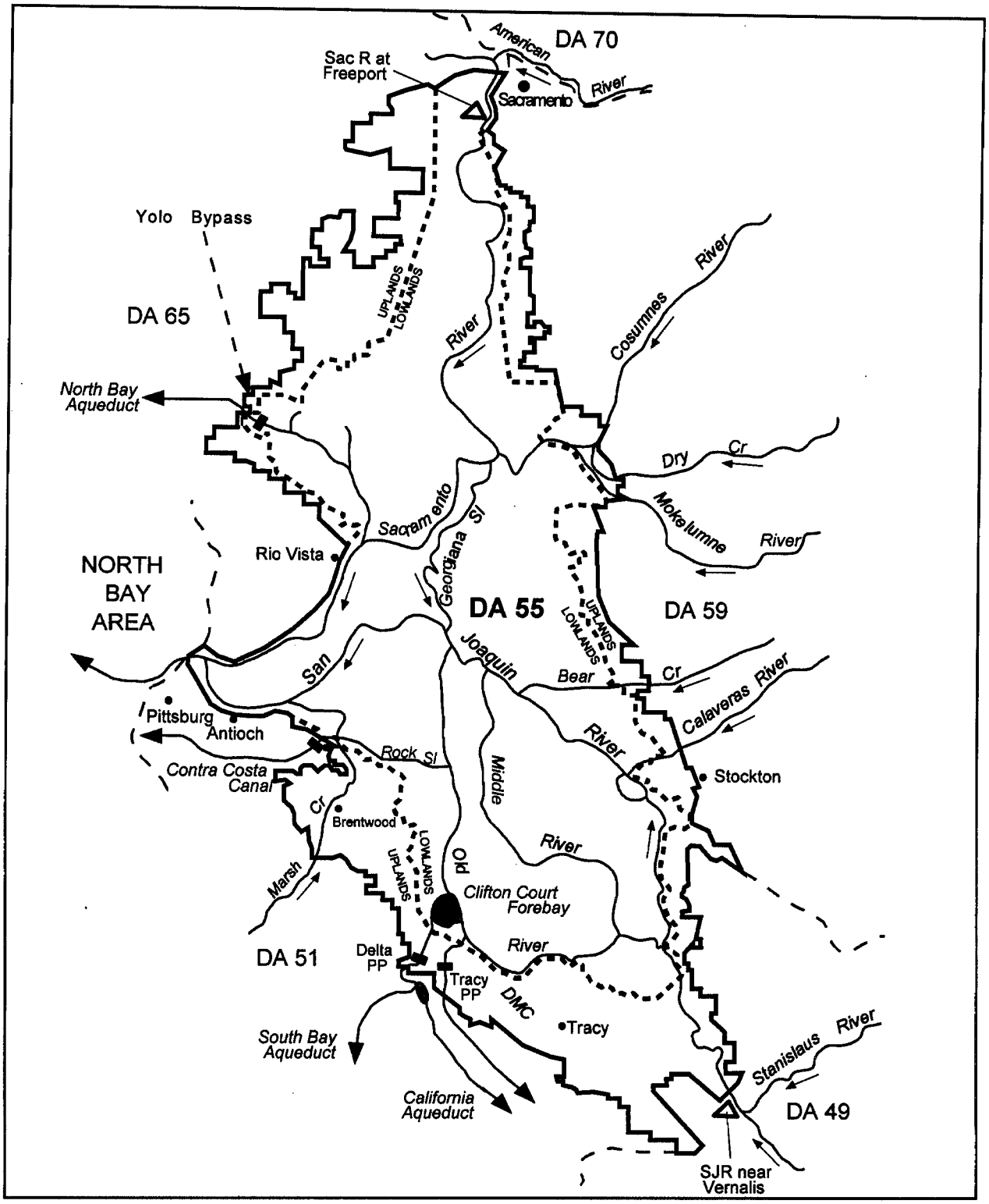


Figure 53: Depletion Area 55 Map

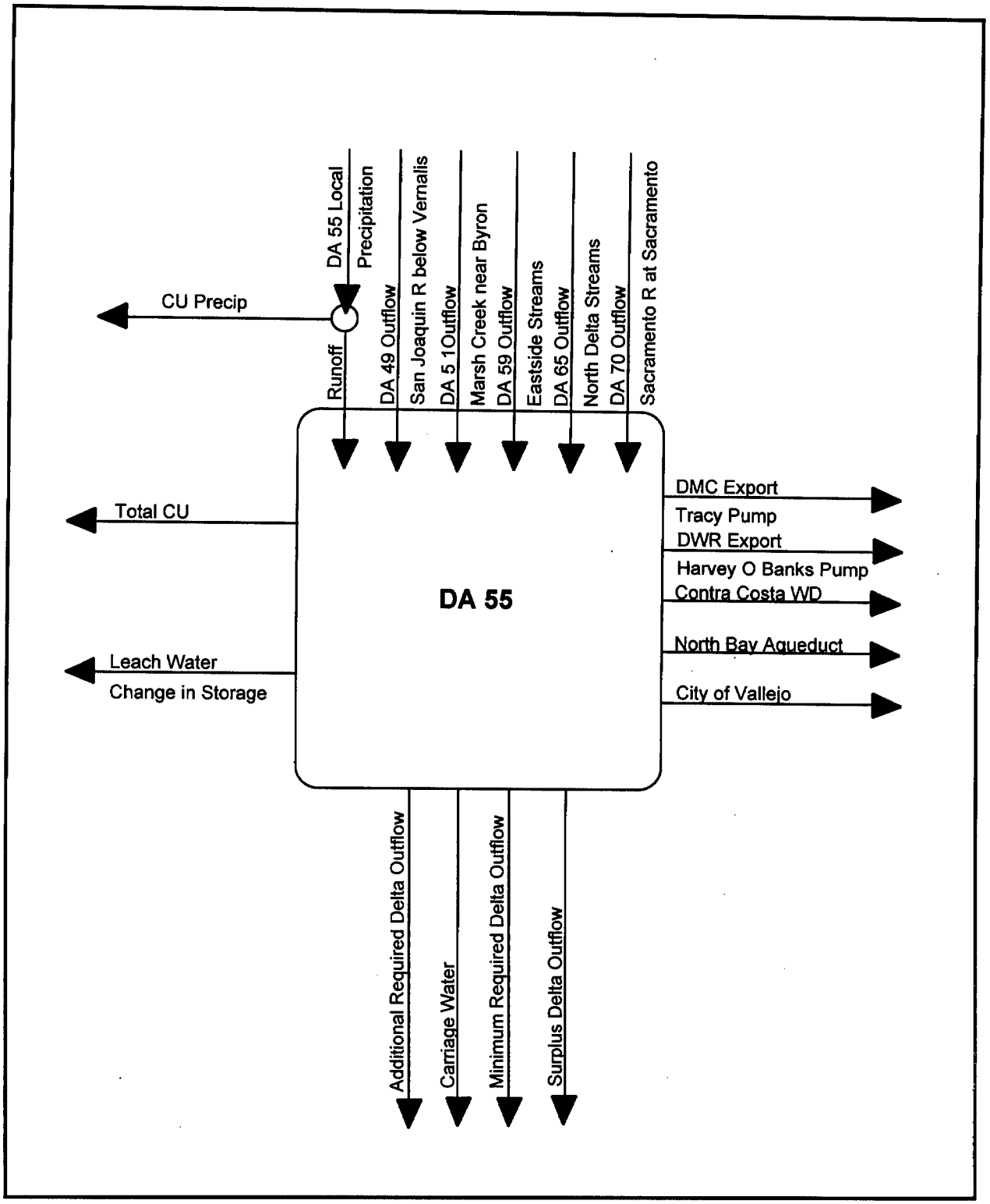


Figure 54: Depletion Area 55 Schematic

DEPLETION AREA 58
SACRAMENTO RIVER ABOVE RED BLUFF

Depletion Area 58 is located at the northern part of the Sacramento Valley floor. It covers the segment of the Sacramento River from Lake Shasta to just above Red Bluff. It is the drainage area for Cottonwood Creek and other local minor creeks. Whiskeytown Lake is the major reservoir in DA58.

A modification to remove the effects of Whiskeytown Reservoir and Trinity River imports is built into DA58. A modification to remove the effects of Shasta Reservoir is built into the upstream depletion area 62.

Project water to simulate Projected Whiskeytown releases to supply Clear Creek water rights and fish is also built into DA58.

PROJECT OUTFLOW: The projected outflow of DA58 is calculated as:

+ Historic Outflow
+ Basin Modification
+ Upstream Area Modification from DA62
+ Historic Depletion
- Projected Depletion

HISTORIC OUTFLOW: The historic outflow of DA58 is defined as the flow of the Sacramento River at Red Bluff. Prior to October 1968, the gage was located just upstream from the Red Bluff Diversion Dam. Measured flows included the flow of Paynes Creek. Monthly flows were taken from the USGS Water Resources Data reports.

In October 1968, the Red Bluff gage was relocated upstream and renamed Sacramento River above Bend Bridge, near Red Bluff. Flows at the new location did not include the flow of Paynes Creek. Therefore, beginning in October 1968, the historic outflow of DA58 was computed as the sum of the Sacramento River above Bend Bridge, near Red Bluff plus 1.12 times the flow of Paynes Creek near Red Bluff. The Sacramento River flows were taken from USGS Water Resources Data reports. Paynes Creek flows had to be estimated since the USGS gage Paynes Creek near Red Bluff was discontinued in September 1966. Annual flows were extended by correlation with Mill Creek near Los Molinos. Monthly distribution was assumed the same as the precipitation pattern at the Red Bluff Airport precipitation gage.

BASIN MODIFICATION: This basin modification removes the historic effects of Whiskeytown Reservoir and Trinity imports. The modification begins in May 1963 and is equal to the change in storage and evaporation of Whiskeytown Reservoir minus Trinity River import through Judge F. Carr power plant. The data was taken from USGS Water Resources Data reports.

PROJECT WATER: Project waters in DA58 represent storage withdrawals from Whiskeytown Reservoir required to satisfy Clear Creek fish flows and water rights. No project waters from Shasta were needed to meet DA58 Sacramento River CVP demands.

Since the completion of Whiskeytown Reservoir in 1963, at least 3 TAF/month has been released to Clear Creek during the January through October period and 6 TAF/month in November and December. Project water is the amount of water required from storage, when inflows are too small to meet the required fish flows and water rights.

Whiskeytown inflow prior to 1963 are from USBR computations and from USBR Report of Central Valley Operations beginning 1963.

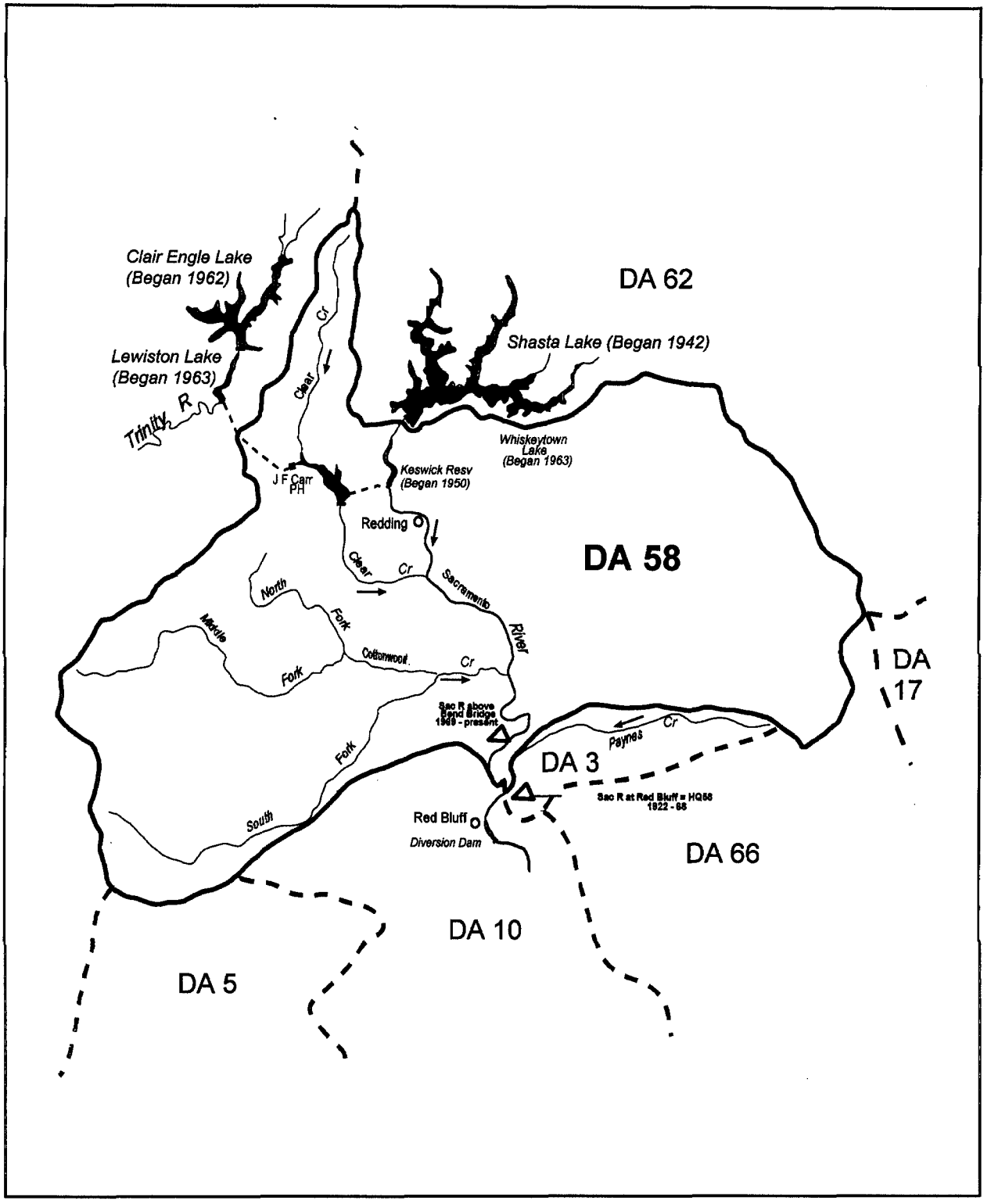
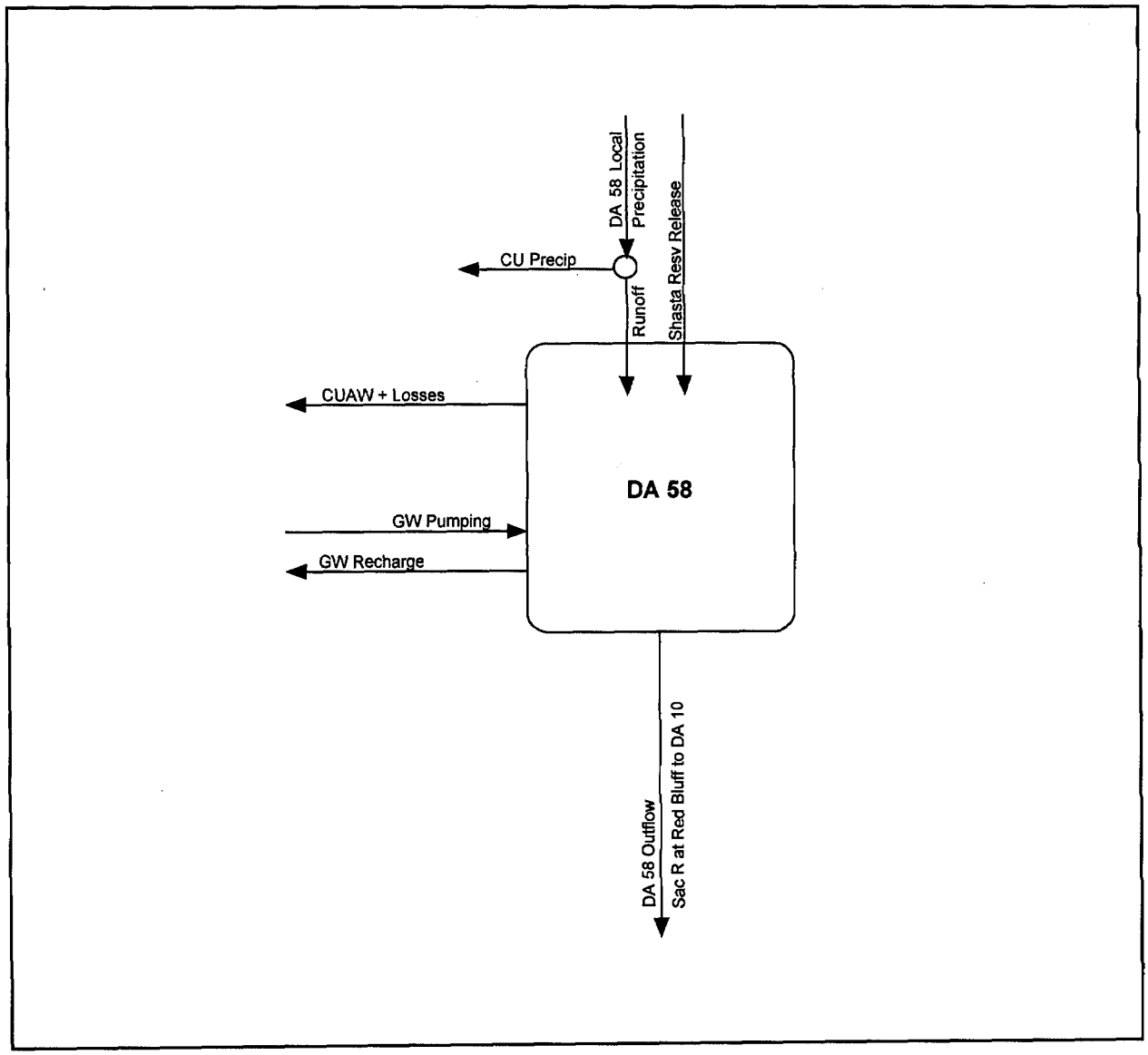


Figure 55: Depletion Area 58 Map


DA 58 Local Precipitation
Shasta Resv Release
CU Precip
Runoff
CUAW + Losses
DA 58
GW Pumping
GW Recharge
DA 58 Outflow
Sac R at Red Bluff to DA 10

DEPLETION AREA 59
VALLEY FLOOR EAST OF THE DELTA

Depletion Area 59 is a valley floor area located between the American River on the north and the Stanislaus River to the south. It is drainage for several streams flowing into the delta along the eastern edge. The major rivers are the Cosumnes, Mokelumne, and Calaveras. A list of most of the streams are in the table below.

DA59 Eastside Streams (by north to south location):

- Morrison Creek
- Elder Creek (unmeasured)
- Laguna Creek (unmeasured)
- Cosumnes River
- Dry Creek
- Mokelumne River
- Bear Creek
- Calaveras River
- Stockton Diverting Canal
- Mormon Slough
- Duck Creek
- French Camp Slough

Runoff from most of the streams is only periodically measured leaving an unmeasured area that has to be estimated. The unmeasured area is estimated by multiplying the Dry Creek near Galt runoff by an area-runoff ratio. Details of the historic outflow estimate is presented under 'HISTORIC OUTFLOW'.

Upstream drainage from the largest streams is separated into four depletion areas.

- DA25 Cosumnes River at Michigan Bar
- DA27 Dry Creek near Ione
- DA29 Mokelumne River above Camanche Reservoir
- DA32 Calaveras above Jenny Lind

DA59 imports water from the American River through Folsom-South Canal.

About half of the urban water developed at Stockton Treatment Plant (20 TAF/year) is exported to the Stockton urban areas located in the Delta.

Historic ground water overdraft conditions exist in DA59. An historic ground overdraft adjustment is made in the model.

A minimum flow on the Mokelumne and Calaveras River of 20 TAF/yr is maintained during the winter months.

PROJECTED OUTFLOW: The projected outflow of DA59 is calculated as:

+ Historic outflow
- Historic import Folsom South Canal
+ Projected import Folsom South Canal
+ Historic ground water overdraft adjustment
+ Historic subsurface inflow overdraft adjustment
+ Upstream modifications, DA's 25, 27, 29, and 32
+ Historic depletion
- Projected depletion
+ Projected additional ground water pumping
- Projected additional ground water recharge

HISTORIC OUTFLOW: Historic outflow from Depletion Area 59 is the inflow to the Delta of all eastside streams between the American River (DA70) and Stanislaus River Total flow is obtained by adding an estimated unmeasured runoff to the gaged flows of several rivers and creeks.

The unmeasured runoff is calculated as an area-runoff factor times Dry Creek flow near Galt

The table on the next page shows how the unmeasured area-runoff factors were developed. The table below is a list of the measured flows used.

The 1990-92 area/runoff factor has been made the same as 1988-89. We were able to find the Mokelumne at Woodbridge data which we will use in place of the below Camanche data, thus eliminating the need for unmeasured Woodbridge to Camanche runoff. Update was made for the B160-93 hydrology on 9/8/93.

Measured Flows Used in DA59, Eastside Streams Outflow Calculation:

	1922-41	1942-44	1944-49	1949-54	1955-59	1959-70	1971	1972-82	1983-85	1986	1987	1988-89	1990-91
Consumnes at Michigan Bar	XX	--	--	--	--	--	--	--	XX	XX	XX	XX	XX
Consumnes at McConnell	--	XX	XX	XX	XX	XX	XX	XX	--	--	--	--	--
Dry Creek near Ione	--	--	--	--	--	--	--	--	--	--	--	--	--
Dry Creek near Galt	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Mokelumne at Woodbridge	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	*XX
Mokelumne below Camanche Res.	--	--	--	--	--	--	--	--	--	--	--	--	*
Bear Creek above Lockford	--	--	--	--	XX	XX	XX	XX	XX	--	--	--	--
Calaveras at Jenny Lind	XX	XX	XX	--	--	--	--	--	--	--	--	--	--
Calaveras near Stockton	--	--	--	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Stockton Diverting Canal	--	--	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Duck Creek above Stockton	--	--	--	--	XX	XX	--	XX	XX	XX	--	--	--
French Camp Sl. above French Camp	--	--	--	--	XX	XX	XX	XX	XX	XX	XX	XX	XX
Morrison Creek	--	--	--	--	--	XX	XX	XX	XX	XX	XX	--	--

* Updated 9/8/93 Mokelumne at Woodbridge found in USGS, Volume 4.

Unmeasured Area - Runoff for DA59, Eastside Streams: (Area = Mile^2)

Area	DA59 Sub-Units	'22-'41	'42-'44	'44-'49	'49-'54	'55-'59	'59-'70	'71	'72-'82	'83-'85	'86	'87	'88-'89	'90-'91
99	25 Unnamed DA25	99	--	--	--	--	--	--	--	*	*	*	*	*
65	26 Consumnes: Michigan to Mconnell	65	--	--	--	--	--	--	--	65	65	65	65	65
23	26N Deer Creek	23	--	--	--	--	--	--	--	23	23	23	23	23
110	28 Dry Creek: Galt to DA27	--	--	--	--	--	--	--	--	--	--	--	--	--
80	30Mokclumne: Woodbridge to Camanche	--	--	--	--	--	--	--	--	--	--	--	--	**_
48	31 Bear Creek above Lockford	48	48	48	48	--	--	--	--	--	48	48	48	48
117	33 Calavcras: Stockton to Jenny Lind	117	117	60	--	--	--	--	--	--	--	--	--	--
105	35 Stockton Diverting Canal, B02580	105	105	--	--	--	--	--	--	--	--	--	--	--
51	36 Duck Creek above Stockton	51	51	51	51	--	--	51*	--	--	--	51	51	51
112	34 Gopher Ridge	112	112	112	112	--	--	--	--	--	--	--	--	--
221	38 French Camp Sl. above French Camp	221	221	221	221	--	--	--	--	--	--	--	--	--
32	37 Unmeasured: Duck to Littlejohns Cr.	32	32	32	32	32	32	32	32	32	32	32	32	32
65	50 Unmeasured Portion: SU's 38 and 55	--	--	--	--	--	--	--	--	--	--	--	--	--
133	53 Unmeasured: American to Mokelumne	133	133	133	133	133	133	133	133	133	133	133	133	133
-49	Less Morrison Creek	--	--	--	--	--	-49	-49	-49	-49	-49	-49	--	--
474	54 Upstream Part of SU 53	474	474	474	474	474	474	474	474	474	474	474	474	474
1524	DA 59 Total Unmeasured Area	1480	1293	1131	1071	639	590	641	590	678	726	777	826	826
	Area-Runoff Factor = Unms'd Area * 2"	2960	2586	2262	2141	1278	1180	1282	1180	1356	1452	1554	1652	1652
	Dry Creek Area	325	325	325	325	329	329	329	329	329	329	329	329	329
	Dry Creek Area * 4.3"	1398	1398	1398	1398	1415	1415	1415	1415	1415	1415	1415	1415	1415
	Area-Runoff Factor = A/B	2.12	1.85	1.62	1.53	0.903	0.834	0.906	834	0.959	1.026	1.098	1.168	1.168

* 99 Square Miles erroneously left out of c01, c01a, c01b, c02, and c02a studies.
Area-Runoff Factor = (Unmeasured area * 2" Runoff) / (Dry Creek Area * 4.3" Runoff)

10/21 - 9/54 Historic outflow was computed using data from the 1957 DWR/USBR Joint Hydrology Study. The Joint Hydrology Tables are combined in a somewhat complicated manner. After uncombining a number of tables, you get what is called historic Eastside Streams flow. The following is a more straight forward way of obtaining the historic outflow using Eastside Streams items from:

1957 Joint Hydrology Study			
	Table 126	Table 127	
	December	May	August
Consumes River	14	97	0.8
Dry Creek	9	6	0
Mokelumne River	11	309	6.2
Stockton Diverting Canal	--	--	--
Calaveras	14	9	0
Unmeasured	19	13	0.0*
Eastside Streams	67	434	7**

* Unmeasured equals to 2.12 times Dry Creek.
** "6" was used instead of "7".

10/54 - 9/91 The historic outflow was estimated as the sum of the gaged flows of Cosumnes River at McConnell, Mokelumne River at Woodbridge, Bear Creek near Lockford, Morrison Creek near Sacramento, Calaveras River near Stockton, Stockton Diverting Canal at Stockton, Duck Creek near Stockton, French Camp Slough at French Camp, and Dry Creek near Galt plus runoff from unmeasured areas. Runoff from Cosumnes River, Mokelumne River, Bear Creek, Morrison Creek, and Dry Creek were taken from USGS Water Resources Data reports. Runoff from Calaveras River, Stockton Diverting Canal, Duck Creek near Stockton, and French Camp Slough were taken from DWR Water Supervision reports.

EXPORT: DA59 covers the southern portion of Sacramento County and the northern portions of San Joaquin and Stanislaus Counties. It includes the downtown and south areas of the city of Sacramento and the east half of the city of Stockton.

Urban water developed at the Stockton treatment plant serves both east and west halves of

Stockton. Since the west half of Stockton is located in the delta, half of Stockton Treatment Plant water is assumed to be exported. Annual amount treated is estimated to be 40 TAF/year for which 20 TAF/yr is exported.

Most urban water for the city of Sacramento comes from the American and Sacramento Rivers, located in DA70. Returns from domestic (in house) and landscape irrigation is returned either at the Regional Sanitation District plant at Freeport or at the storm drains along the Sacramento and American Rivers. With the downtown portion of the City located in DA59, the correct depletion analysis modeling of the water supply and return flows would be to import an estimated supply from DA70 and export an estimated return to DA70. To avoid the import/export bookkeeping and simplify the depletion analysis procedure, the city of Sacramento's urban land areas located in DA59 are transferred to the urban land areas in DA70. This is done in the input data to the consumptive use phase of the depletion analysis.

DA59 includes the area served by Folsom-South Canal. Folsom-South Canal diverts water from the American River at Lake Natoma in DA70. In earlier depletion studies, Folsom-South Canal was expected to supply 400 to 500 TAF/yr to irrigated agriculture in both Sacramento and San Joaquin Counties. At one time it was hoped that Folsom-South Canal imports would alleviate the ground water overdraft problem in the area.

Historic diversion in Folsom-South Canal began in 1973. For the last ten years the canal has averaged 30 TAF/year. The dry years 1990 and 1991, diversion is cut back to less that 20 TAF/year. Much of the water goes to SMUD's ponds. SMUD originally used to water as cooling water in the nuclear power plant at Rancho Seco. The plant is no longer operating, but SMUD still receives its allotment.

BASIN MODIFICATION: Basin modifications for DA59 include removal of historic Folsom South Canal import, historic groundwater adjustment, historic subsurface inflow adjustment and an adjustment to redistribute shortages.

Historic Folsom South Canal import was calculated by subtracting the historic SMUD deliveries from the historic Folsom South Canal data found in USBR Monthly Reports of Operations.

Historic groundwater overdraft was assumed to begin in water year 1945 and gradually increase to 100 TAF/yr by 1955. The groundwater overdraft indicated no pronounced trend as observed by the USBR from 1955 to 1967, but it increases from 100 TAF to 120 TAF by 1972. From WY 1972 to WY 1980 the groundwater overdraft was estimated by calculating the percentage of yearly land use totals to that of 1972. The percentages were used to multiply by the 1972 groundwater overdraft minus the historic Folsom South Canal to agriculture to obtain the present year's groundwater overdraft.

Sub-surface inflow is described as delta ground water moving into DA59's ground basin as a result of falling water levels. The sub-surface inflow was estimated as one half of the groundwater overdraft.

The ground water and sub-surface inflow adjustments were distributed on the same pattern as the historic consumptive use of applied water.

Projected Folsom South Canal import, as well as Stanislaus River import was assumed to be zero in this initial depletion study. In a later study, projected Folsom South Canal import for agriculture will be set at 22 TAF/yr and Stanislaus River imports will range from 105 to 152 taf/yr.

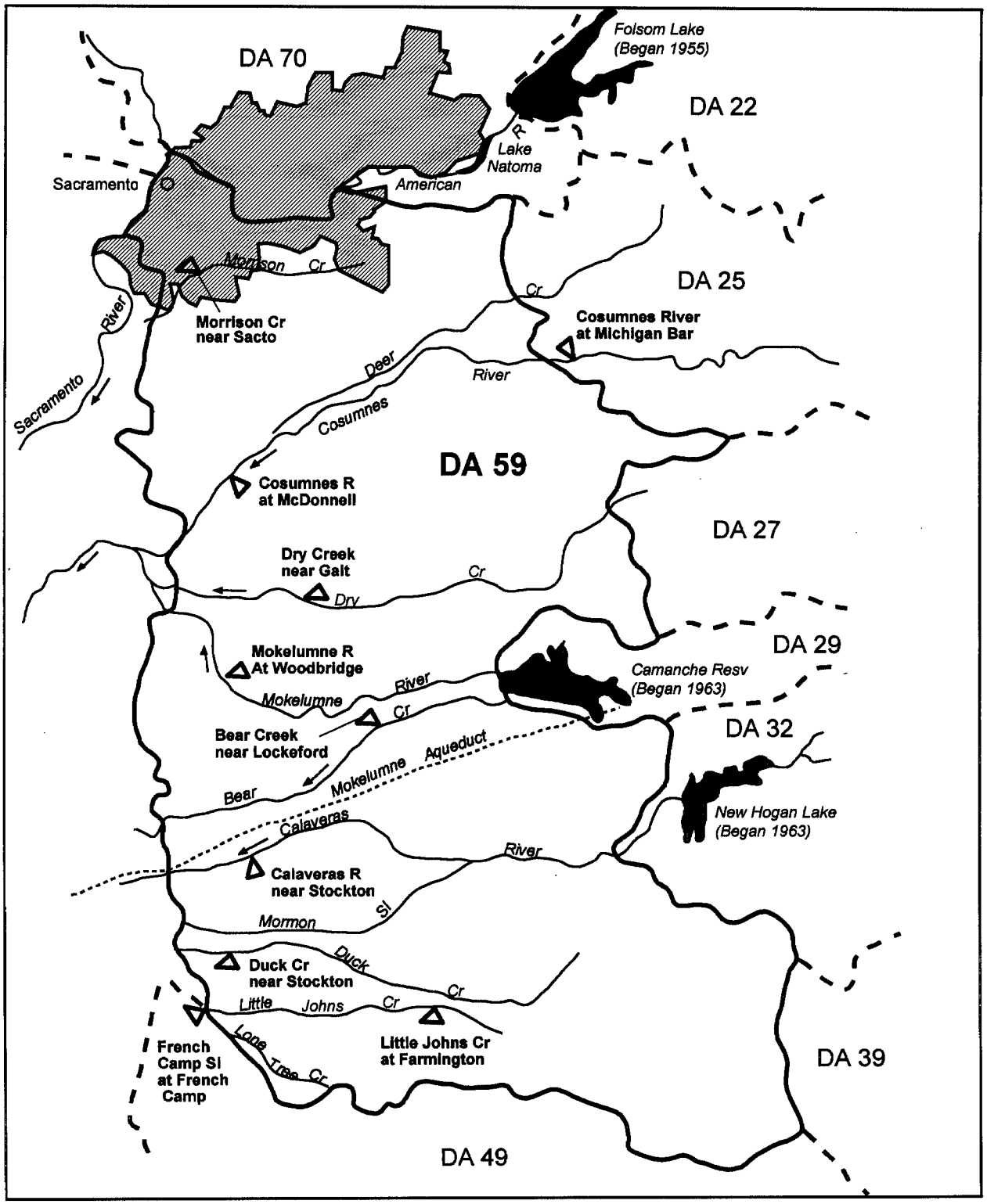


Figure 57: Depletion Area 59 Map

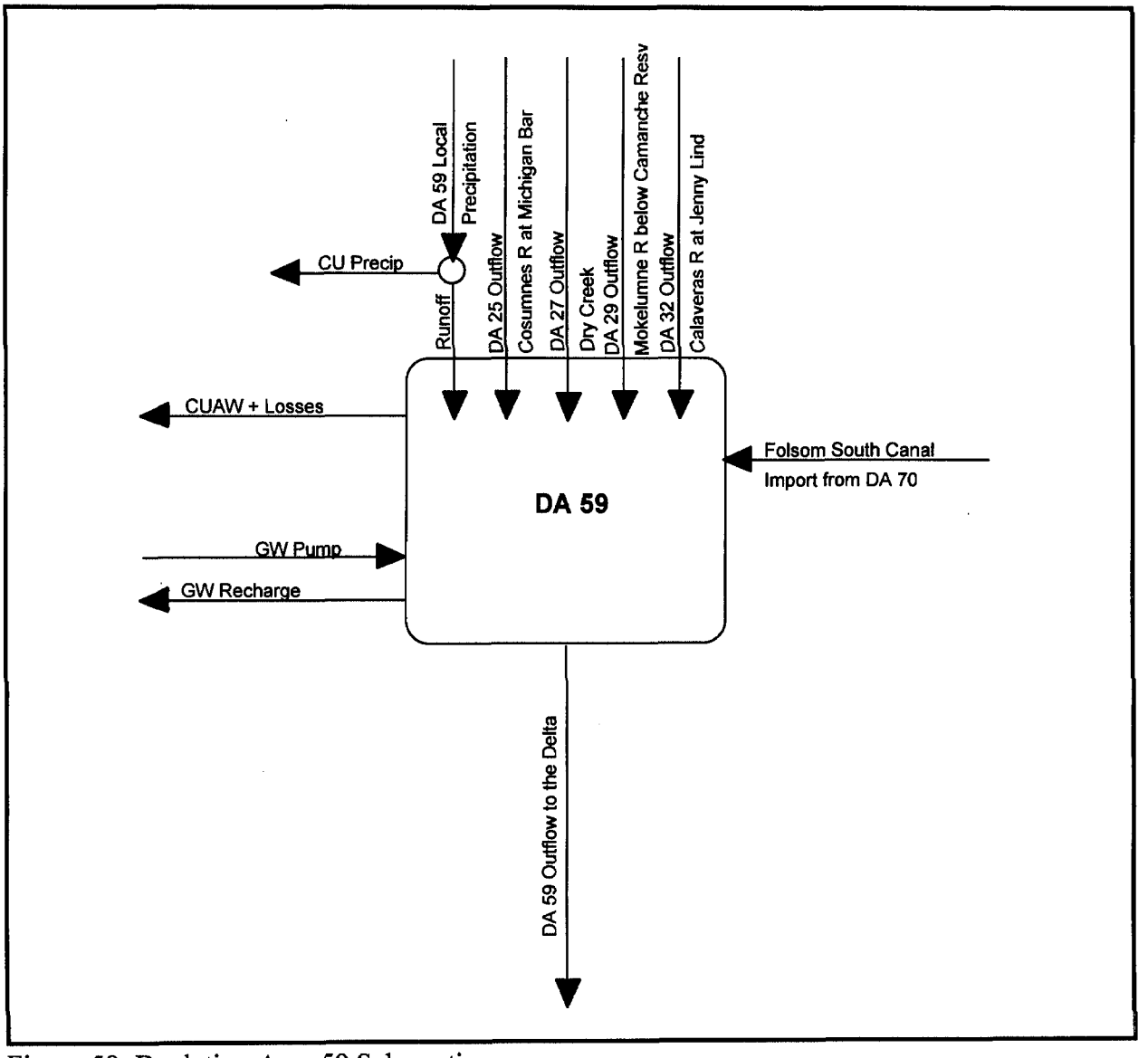


Figure 58: Depletion Area 59 Schematic

DEPLETION AREA 61
PIT RIVER AT FALL RIVER MILLS

Depletion Area 61 is located on the northeast side of DA62. It is the drainage area for the Pit River from Fall River Mills to Alturas. The three major reservoirs located in DA61 are Big Sage Reservoir, Lower Roberts Reservoir, and Big Lake.

DA61's export is the Fall River Diversion through Pit No. 1 Powerhouse.

PROJECTED OUTFLOW: The projected outflow of DA61 is calculated as:

+ Historic Outflow
+ Historic Export
- Projected Export
+ Historic Depletion
- Projected Depletion
+ Projected Additional Ground Water Pumping
- Projected Additional Ground Water Recharge

HISTORIC OUTFLOW: The historic outflow of DA61 is the Pit River at Fall River Mills.

10/21 - 9/51 Monthly flows were taken from USGS Water Resources Data reports.

Monthly flows for the period October 1922 through February 1923 were estimated by correlating USGS partial daily flows of the Pit River above Fall River Mills with the Pit River near Bieber. Beginning in October 1922 the flow of the Pit River near Fall River Mills was sharply reduced by PG&E's diversion through Pit No. 1 Powerhouse.

10/51 - 9/66 Monthly flows were obtained directly from PG&E.

10/67 - 7/75 Monthly flows were estimated by the DWR Northern District by correlation with Pit River near Bieber.

8/75 - 9/91 Monthly flows were computed as the flow at Pit No. 1 Powerhouse near Fall River Mills less PG&E's Fall River diversion.

HISTORIC EXPORT: Historic export for DA61 is the Fall River diversion through Pit No. 1 Powerhouse. Historic export began in October 1922. Diversion data was obtained from PG&E records.

PROJECTED EXPORT: The projected export is the same as historic, except for the first two years. For the period October 1921 through October 1923, the projected export was estimated to be equal to the flow of Fall River at Fall River Mills less an estimated 20 cubic feet per second for the downstream irrigation rights from April 1 to October 15.

HISTORIC DEPLETION: Because of a limited water supply in the Upper Pit drainage area, the historic depletion was reduced 10% each month during critical years. Critical years are 1924, 1929, 1933, 1934, 1939, and 1977. A critical year begins in January and ends in December.

A further reduction is made every year in the months of June through September. The percentage of reduced depletion was calculated from average irrigated crop areas in Big Valley during the years 1954-58. The irrigation practices are described in DWR Bulletin 86, "Upper Pit River Investigation", November, 1960.

The percentage and areas are as follows:

	May	Jun	Jul	Aug	Sep-Dec
Irrigated Area, in acres	24,130	16,920	10,400	8,210	9,100
Percent irrigated	100	70	43	34	38

Note: Computed in COMP model file: pm61.cu

PROJECTED DEPLETION: Projected depletion is equal the projected consumptive use of irrigated and urban areas plus non-recoverable loss of 10% of cu of applied water. Projected consumptive use has been reduced for deficiencies and irrigation season shortages in the same way as the historic depletion.

PROJECTED ADDITIONAL GROUND WATER PUMPING AND RECHARGE: Additional storage regulation up to 206 TAF is needed to satisfy the diversion requirements in this area. Storage operation is calculated in the Depletion Analysis.

It should be noted that changing diversion efficiency factors back to the old 76WAP values has effected the additional ground water storage operation and, thus, the upstream area modification to DA62 and IN4, the projected inflow to Shasta Reservoir. This depletion analysis was rerun on 11/15/89. IN4 tables created prior to 11/89 have slight differences (up to 5 TAF).

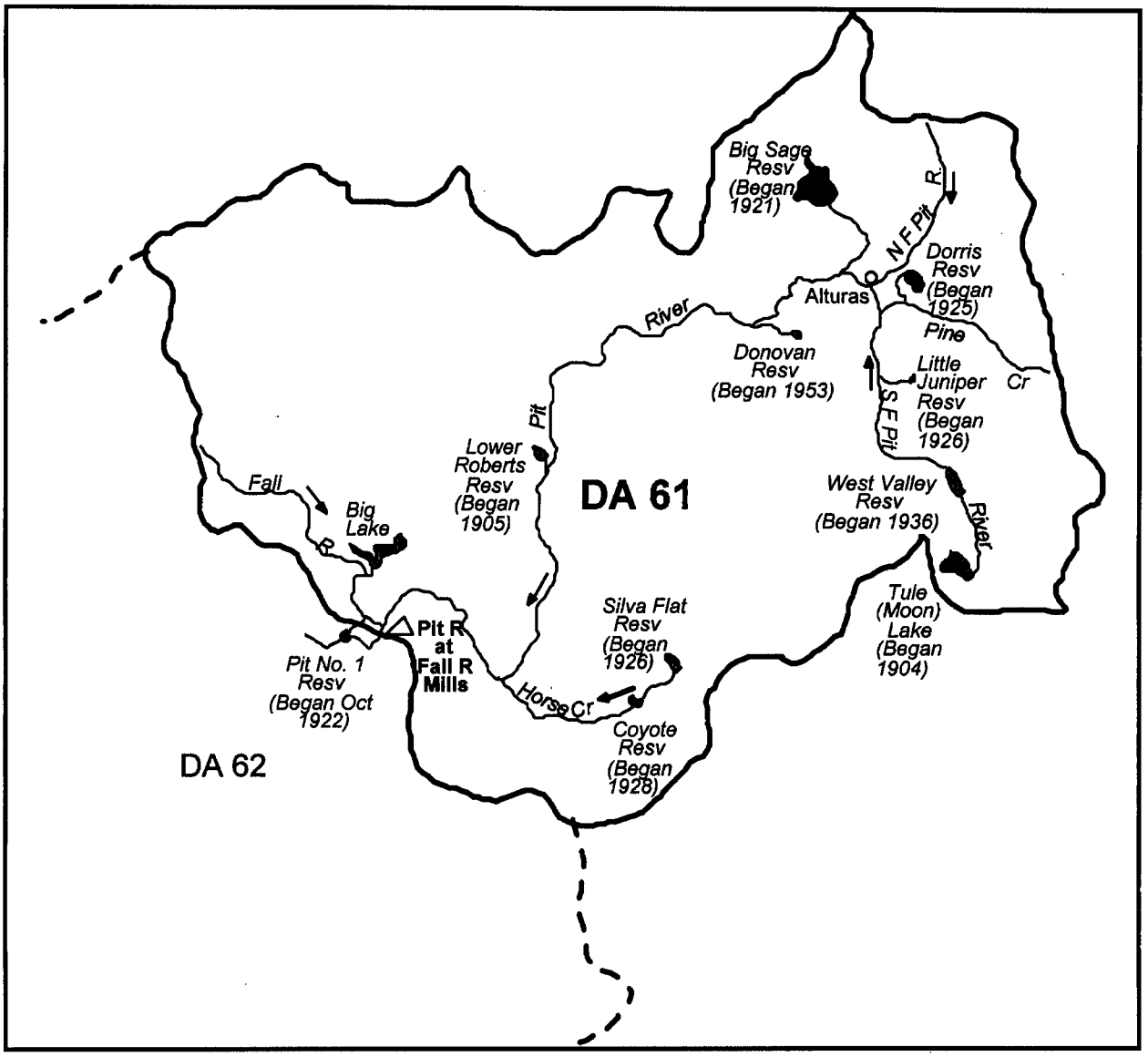


Figure 59: Depletion Area 61 Map

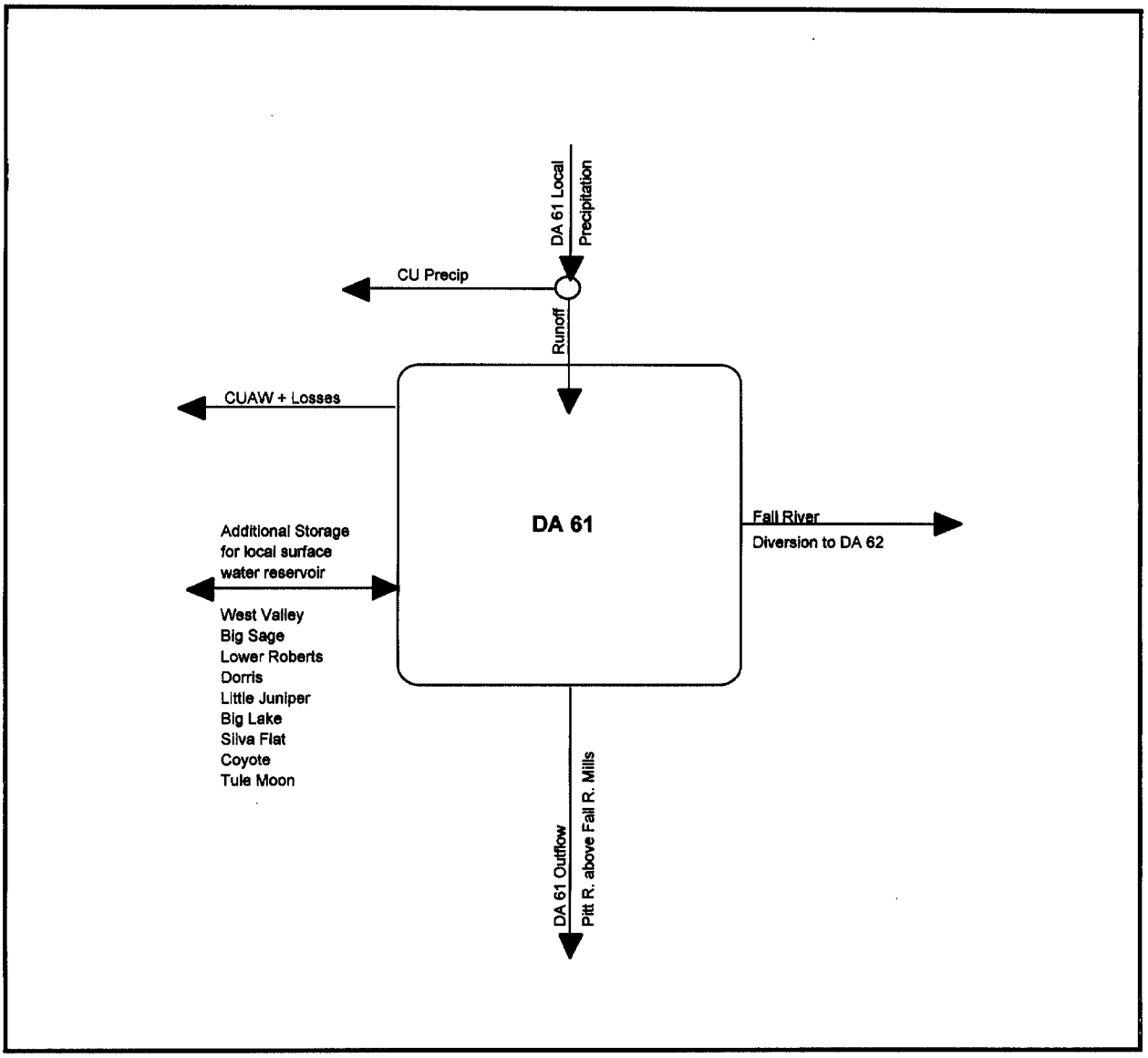


Figure 60: Depletion Area 61 Schematic

DEPLETION AREA 62
SACRAMENTO RIVER ABOVE SHASTA DAM

Depletion Area 62 covers the northernmost portion of the Sacramento River from Shasta Lake to the origin of the Sacramento River. It also covers the segment of the Pit River from Shasta Lake to Fall River Mills. Shasta Lake is the major reservoir in DA62.

PROJECTED OUTFLOW: The projected outflow of DA62 is calculated as:

+ Historic Outflow
+ Upstream Area Modification from DA61
- Historic DA61 Import
+ Projected DA61 Import
+ Modification to remove Shasta effects
+ Historic Depletion
- Projected Depletion

HISTORIC OUTFLOW:

10/21 - 11/42	Historic outflow of DA62 was taken from Table 3 of the 1957 Joint Hydrology Study report.
12/42 - 9/91	The historic flow equals Shasta Reservoir releases, as reported in the USBR Monthly Reports of Operations. Note that February 1974 and May 1976 have been corrected. February 1974 should be 686 TAF, not 1676 TAF. May 1976 should be 738 TAF, not 238 TAF.

PROJECTED AND HISTORIC IMPORT: The import comes from DA61 Fall River Diversion through Pit No. 1 PH and is described under DA61 documentation.

BASIN MODIFICATION: The only basin modification necessary was to remove the effects of historic Shasta Reservoir.

11/42 - 9/54	This modification equals the historic release from Shasta Reservoir minus the historic inflow to Shasta Reservoir. Releases from Shasta Reservoir were taken from USBR Monthly Reports of Operations. Inflow to Shasta Reservoir was taken from Table 3 of the 1957 Joint Hydrology Study.

10/54 - 9/91	This modification equals the change in storage plus evaporation for Shasta Reservoir. Data were taken from USBR Monthly Reports of Operations.

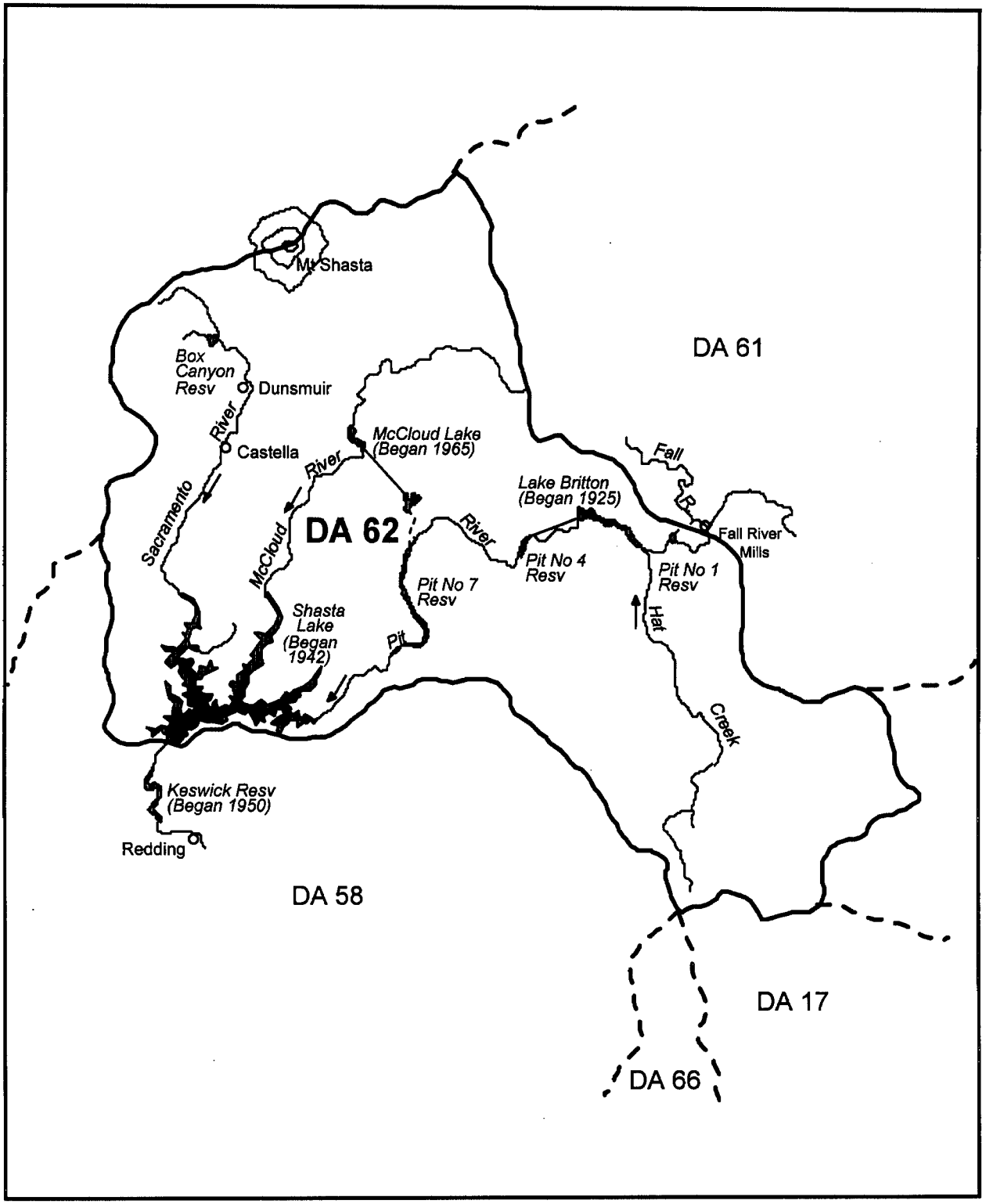


Figure 61: Depletion Area 62 Map

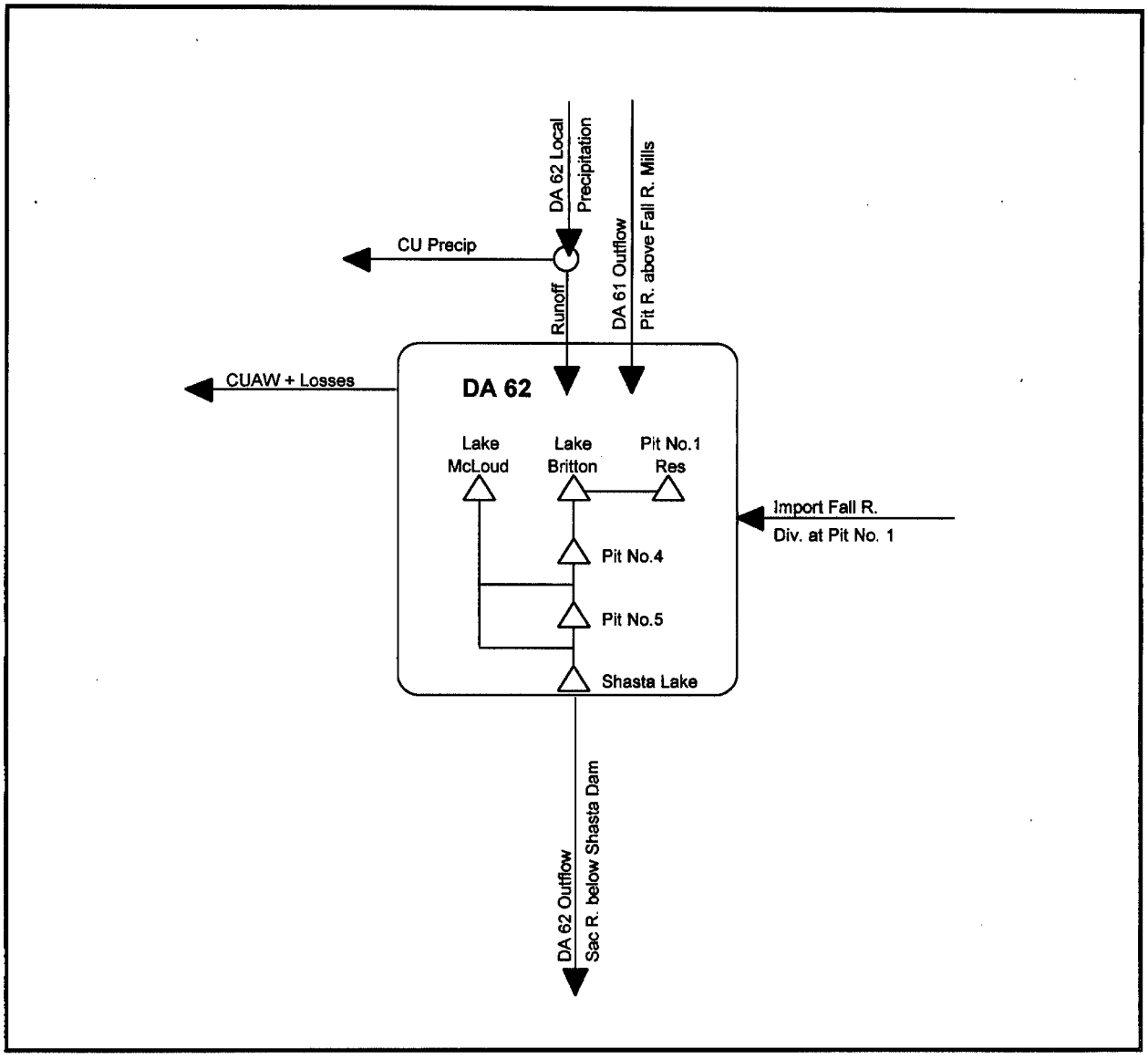


Figure 62: Depletion Area 62 Schematic

DEPLETION AREA 65
NORTH DELTA STREAMS

Depletion Area 65 is the drainage area for the segment of Putah Creek near Winters to the Yolo Bypass and the Putah South Canal. It is also the drainage area for Cache Creek near Rumsey to Yolo. DA65 covers the cities of Woodland, Davis, and Vacaville.

Exports from DA65 includes the flow in the Putah South Canal to the North Bay area.

PROJECTED OUTFLOW: The projected outflow of Depletion Area 65 calculated as:

+ Historic outflow
+ Historic export Putah South Canal to North Bay
- Projected export Putah South Canal to North Bay
+ Increased import Sacramento River right bank diverters
+ Historic groundwater overdraft adjustment
+ Upstream area modification, DA's 16 and 24
+ Historic depletion
- Projected depletion
+ Projected additional ground water pumping
- Projected additional ground water recharge

HISTORIC OUTFLOW: The historic outflow of Depletion Area 65 is equal to the sum of Putah Creek near Davis plus the Yolo Bypass near Woodland plus the estimated North Delta Westside minor streams.

10/21 - 9/48 Putah Creek outflow was estimated by multiplying measured flows of the Putah Creek near Winters by the following factors:

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	.788	.923	.963	.933	.972	.957	.832	.389	0	0	0

The factors were derived from the ratios between Putah Creek flows near Winters and Davis for water years 1948 through 1954. Putah Creek near Winters flows were taken from Table 28 of the 1957 Joint Hydrology Study report. Putah Creek near Davis flows were taken from Table 29 of the same report.

5/48 - 9/91 Data came from USGS Water Supply Reports for Putah Creek near Davis. In January 1963 the gaging station was moved about one mile

downstream and DWR took over measuring the flows. The data is reported in DWR Water Supervision reports under the name "South Putah Creek near Davis".

Yolo Bypass near Woodland

10/21 - 9/54 Data for Yolo Bypass taken from Table 53 of the 1957 Joint Hydrology Study between USBR and DWR.

10/54 - 9/91 Data was taken from the USGS Water Resources Data reports.

North Delta Westside Minor Streams

Outflow of this area is computed by drainage area relationship with Pleasents Creek. For Pleasants Creek data refer to DWR's Memorandum "Input Data for 1980 and 2000 Level Central Valley Depletion Study" dated August 22, 1977 with correction on 1952 through 1954, data came from DWR's "Water Supervision Reports not USGS.

HISTORIC EXPORT: Exports from the area consist of the flow in the Putah South Canal to the North Bay area. Data was estimated to be all M&I deliveries, except those to Vacaville, the Suisun Marsh experiment water (from 1965 through 1971), and 20% of the agricultural water as shown in DWR Bulletin 184 "Ten Counties Investigation."

PROJECTED EXPORT: Exports were assumed to be the projected 1990 deliveries to Vallejo, Fairfield, Suisun and Solano. Napa and Benicia will be supplied entirely by the North Bay Aqueduct beginning in 1988. The agencies prediction of 1990 deliveries from the Putah South Canal are listed as Vallejo 15.7 TAF/yr, Fairfield 14.0 TAF/yr, Suisun 1.2 TAF/yr, Solano 0.9 TAF/yr and Solano agriculture 29.5 TAF/yr. The monthly distribution is based on the previous 1990 level Putah South Canal flow.

BASIN MODIFICATION: Basin modifications for DA65 include increased import from Sacramento river right bank diversions and an adjustment for historic ground water overdraft.

Increased import from Sacramento River right bank diversions equals the water needed in addition to historic Sacramento River right bank diversions and projected import from Knights Landing Ridge Cut to fully meet the projected diversion requirements in the Yolo Bypass service area. Diversion requirements are computed in the Consumptive Use model.

Historic ground water overdraft was estimated by an analysis of the change in water levels in DA65. For additional details see the DWR Memorandum report "Input Data for 1980 and 2000 Level Central Valley Depletion Studies" dated August 22, 1977.

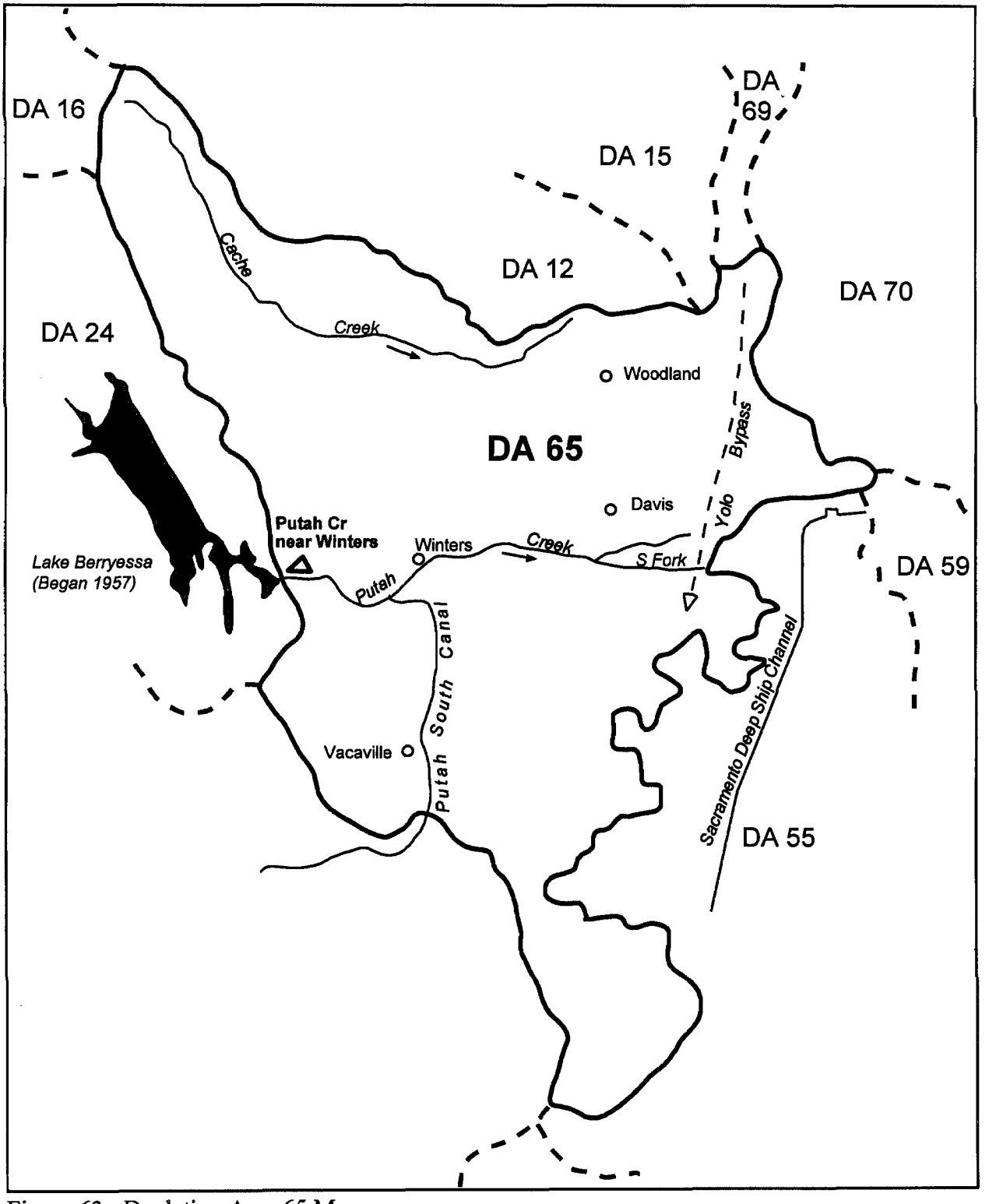


Figure 63: Depletion Area 65 Map

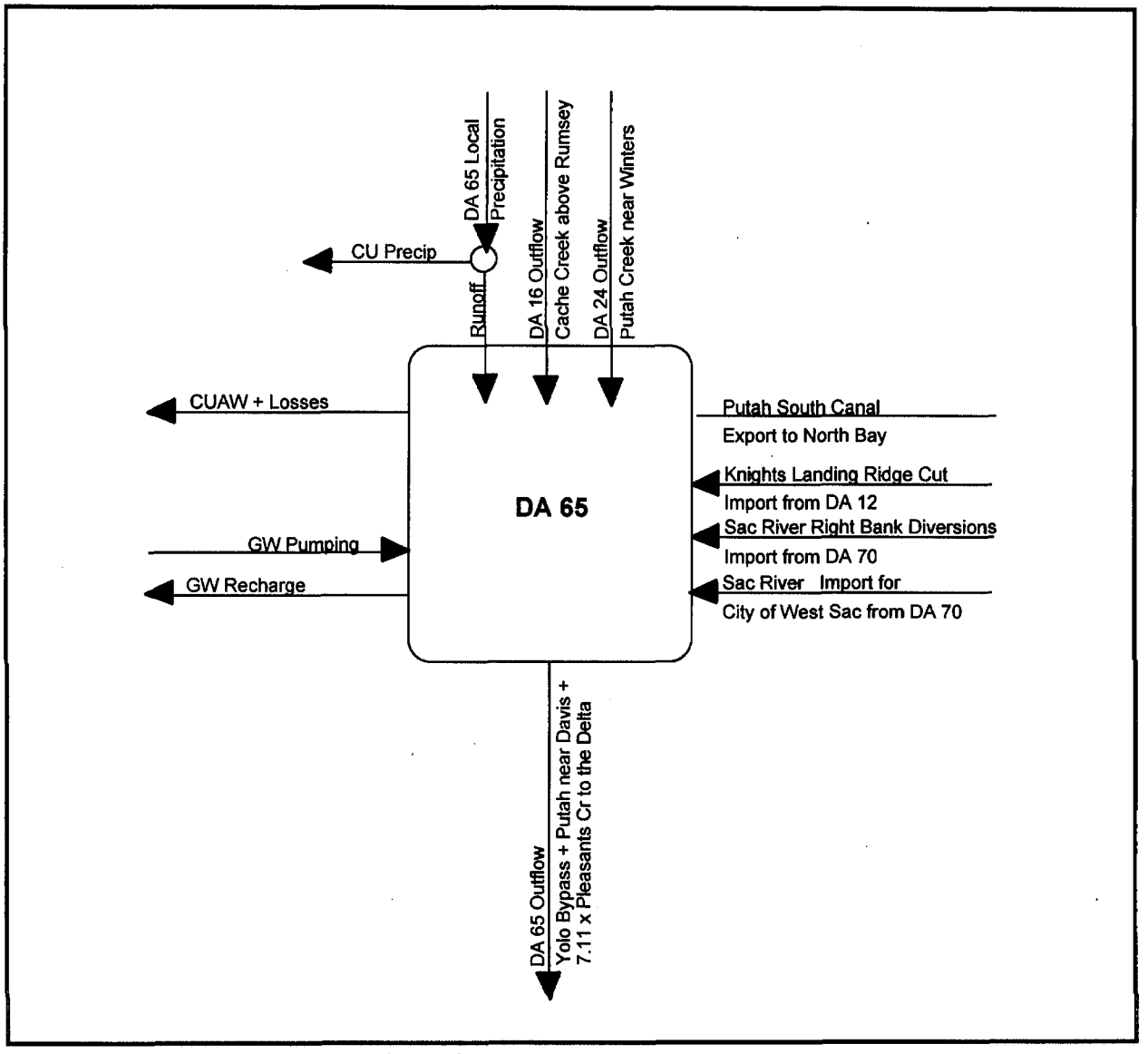


Figure 64: Depletion Area 65 Schematic

DEPLETION AREA 66
SACRAMENTO VALLEY NORTHEAST STREAMS

Depletion Area 66 is the drainage area for a group of creeks which are tributaries to the Sacramento River. These creeks include Antelope Creek, Mill Creek, Dry Creek, Deer Creek, and Big Chico Creek. DA66 is located northeast of DA10.

PROJECTED OUTFLOW: The projected outflow of DA 66 is the same as the historic flow.

HISTORIC OUTFLOW: The historic outflow of Depletion Area 66 equals the combined outflows of Antelope Creek near Red Bluff, Mill Creek near Los Molinos, Deer Creek near Vina, Big Chico Creek near Chico, and an unmeasured area estimated to be (2.595*Antelope Creek near Red Bluff). Measured flows were taken from USGS Water Resources Data reports.

DA66 takes the place of DA's 6, 7, 8, and 9.

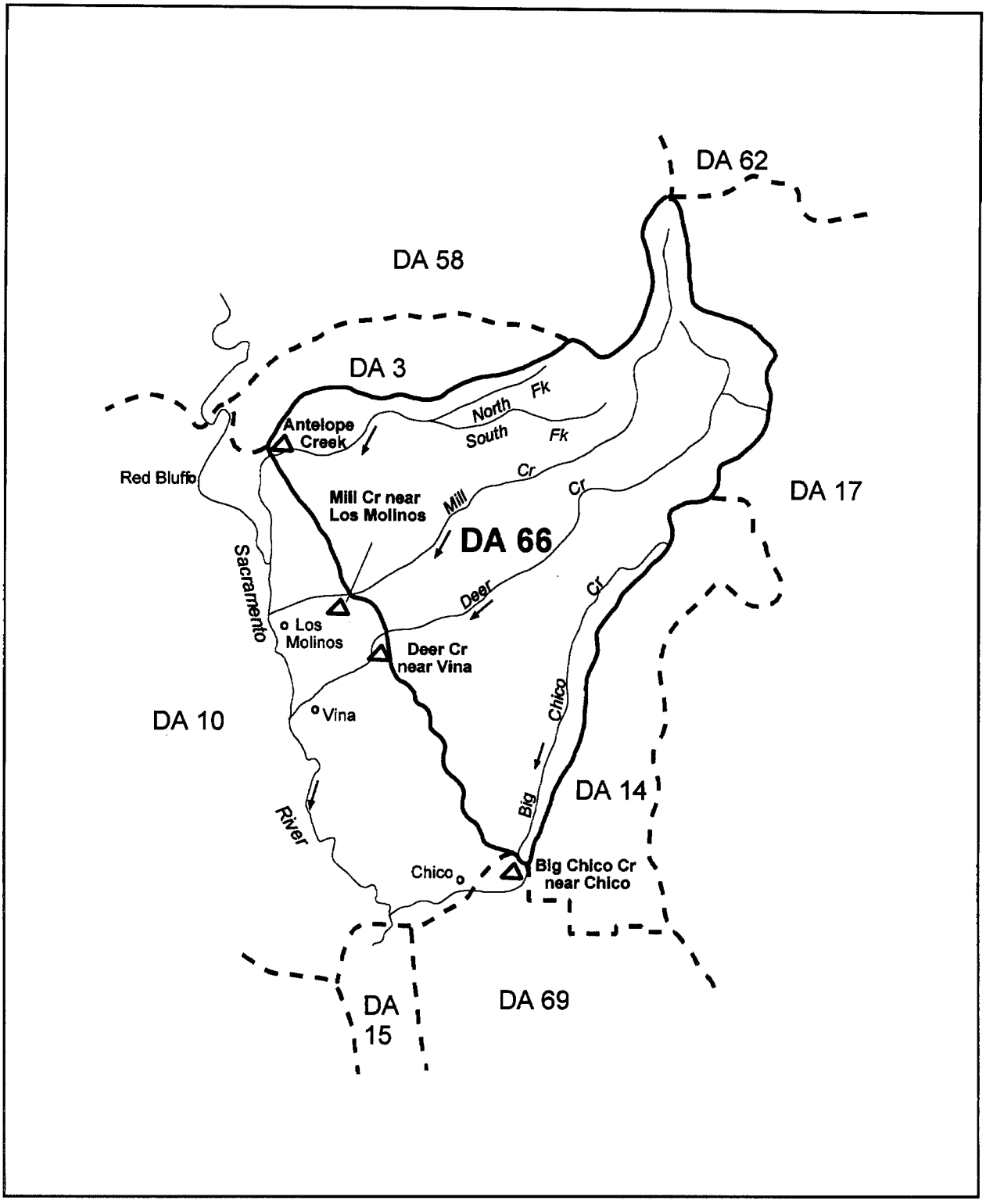


Figure 65: Depletion Area 66 Map

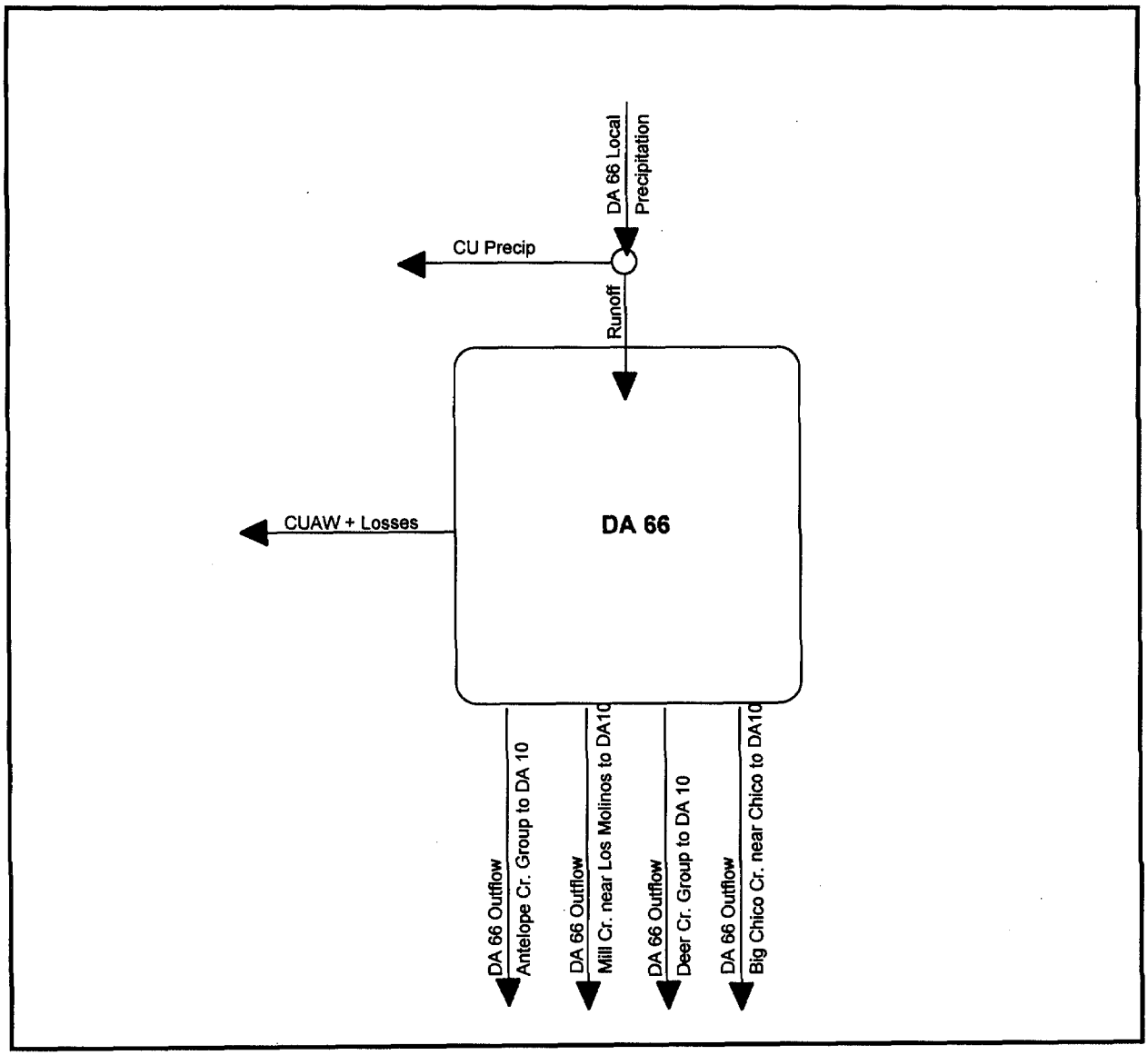


Figure 66: Depletion Area 66 Schematic

DEPLETION AREA 67
YUBA RIVER BELOW DRY CREEK

Depletion Area 67 represents the runoff of the Yuba River below Englebright Reservoir plus the flow from Deer Creek and from Dry Creek. Yuba River joins the Feather River at the towns of Yuba City and Marysville. This is also referred to as the Yuba River near Smartville.

DA67 is located on the east side of the Central Valley between the Feather River to the north and the Bear River to the south.

There are no upstream areas to this depletion area. The downstream area is DA69.

Seven reservoirs are modeled in DA67. The names and capacities are listed in the table below:

Reservoir	Max Capacity (TAF)	Completion Date
New Bullards Bar Reservoir	961.3	1969
Lake Spaulding	74.8	1913
Harry L. Englebright Lake	70.0	1941
Bowman Lake	68.7	1926
Jackson Meadows Reservoir	66.7	1964
Fordyce Lake	49.9	1926
Scotts Flat Reservoir	49.0	1949

Exports are the diversions which transfer water out of the Yuba Drainage area into other areas. DA67 has seven exports. They include:

1. Slate Creek export to DA17, Feather R., from Slate Cr. on the North Fork Yuba R.
2. Browns Valley ditch export to DA69 from French Dry Creek.
3. Drum Canal export to DA68, Bear R., from Lake Spaulding on the S. Fork Yuba R.
4. South Yuba Canal export to DA68 from the S. Fork Yuba River.
5. Cascade Canal export to DA68 from Deer Creek.
6. D-S Canal export to DA68 from Deer Creek.
7. China Ditch export to DA69 from Deer Creek.

Imports transfer water into the Yuba Drainage from outside areas. DA67 has two imports.

They include:

1. South Yuba Canal return from the Bear River.
2. Tarr import from DA69.

HEC3 MODELING: HEC3 Network Simulation Model has been used to represent the entire basin of the Yuba River. The model required 29 Control Points originally. It was revised in June 1989 and the number of the control points was increased to 44. Seven of the control points are for reservoirs. Projected outflow to Depletion Area 69 is the Yuba River flow leaving control point 12. The network diagram for the model is included in Appendix A2.

The computation of the natural flows for each basin segment was done in two steps. The first step was to estimate the natural flow for each basin segment for the period 1922-80. This was normally done by unimpairing a historic gage flow for the period of record and then extending this record by correlation with a nearby station. After the natural flows were computed for all the necessary control points, the second step, a final adjustment, was performed which forced all the upstream flows to sum to the historic unimpaired flow of the gage, "Yuba River near Smartsville".

Unimpaired flow at Smartsville computation is summarized in the table below:

Unimpaired Smartsville Flow Summary
1922-80 Averages (TAF)

Historic Smartsville Flow		1832.0
Historic Imports to Basin		
South Yuba Canal to Deer	46.0	
10% Tarr Ditch	1.5	-47.5
Historic Exports from Basin		
Slate Creek Tunnel	21.2	
Browns Valley Ditch	15.0	
Drum Canal	287.5	
South Yuba Canal Nr Head	63.5	
90% Cascade Ditch	24.8	
85% D-S Canal	18.6	
China Ditch	8.9	+439.5
Historic Crop Depletions		
Above Englebright	10.6	
Above Deer Creek at Smartsville	12.2	+22.8
Historic CU of Replaced Native Vegetation		
Above Englebright	4.7	
Above Deer Creek at Smartsville	6.1	-10.8
Historic Evaporation		
Bowman	1.2	
Bullards Bar	3.6	
Englebright	2.2	
Fordyce	0.3	
French Lake	0.4	
Jackson Meadows	0.4	
Scotts Flat	1.0	
Spaulding	0.5	+9.8
Historic Increase in Storage		
Bowman	0.8	
Bullards Bar	5.7	
Englebright	1.2	
Fordyce	0.3	
French Lake	0.2	
Jackson Meadows	0.9	
Scotts Flat	0.6	
Spaulding	0.0	+9.7
Unimpaired Flow at Smartsville		2254.5

After the natural flows of all the basin segments above Smartsville were estimated, they were summed and compared with the unimpaired flow at Smartsville for each month from October, 1921 thru September, 1980. The unimpaired flows at Smartsville were subtracted from the sum of the upstream natural flows (there were 13 segments above Smartsville) and the differences were distributed. These differences were distributed by multiplying the monthly flows at each of the 13 segments by a factor which reduced the difference to zero.

The averages of the final adjusted natural flows for each of those basin segments are listed in the table below:

CONTROL POINT	1922-80 AVERAGES (TAF)
IN30 Slate creek inflow	135.8
IN13 Wambo Bar Damsite Accretions	746.0
IN2 Jackson Meadows Inflow	78.3
IN21 Hour House Diversion Dam Acc.	200.1
IN25 Oregon Creek Div. Dam Inflow	42.2
IN1 New Bullards Bar Accretions	131.6
IN40 Bowman Lake Inflow	88.5
IN42 Miscellaneous Creeks Inflow	23.2
IN4 Fordyce Inflow	86.0
IN5 Spaulding Accretions	225.9
IN47 Englebright Accretions	404.9
IN6 Scotts Flat Inflow	27.6
IN55 Deer Creek Accretions	64.3
Unimpaired Smartsville	2254.4
IN79 French Dry Creek Inflow	52.3
IN68 Marysville Accretions	52.4
Unimpaired Marysville Damsite	2359.1

Most of the data used in the natural flow computations came from published USGS reports. HEC3 model for DA67 is described in details in "Yuba Rivershed Model report.

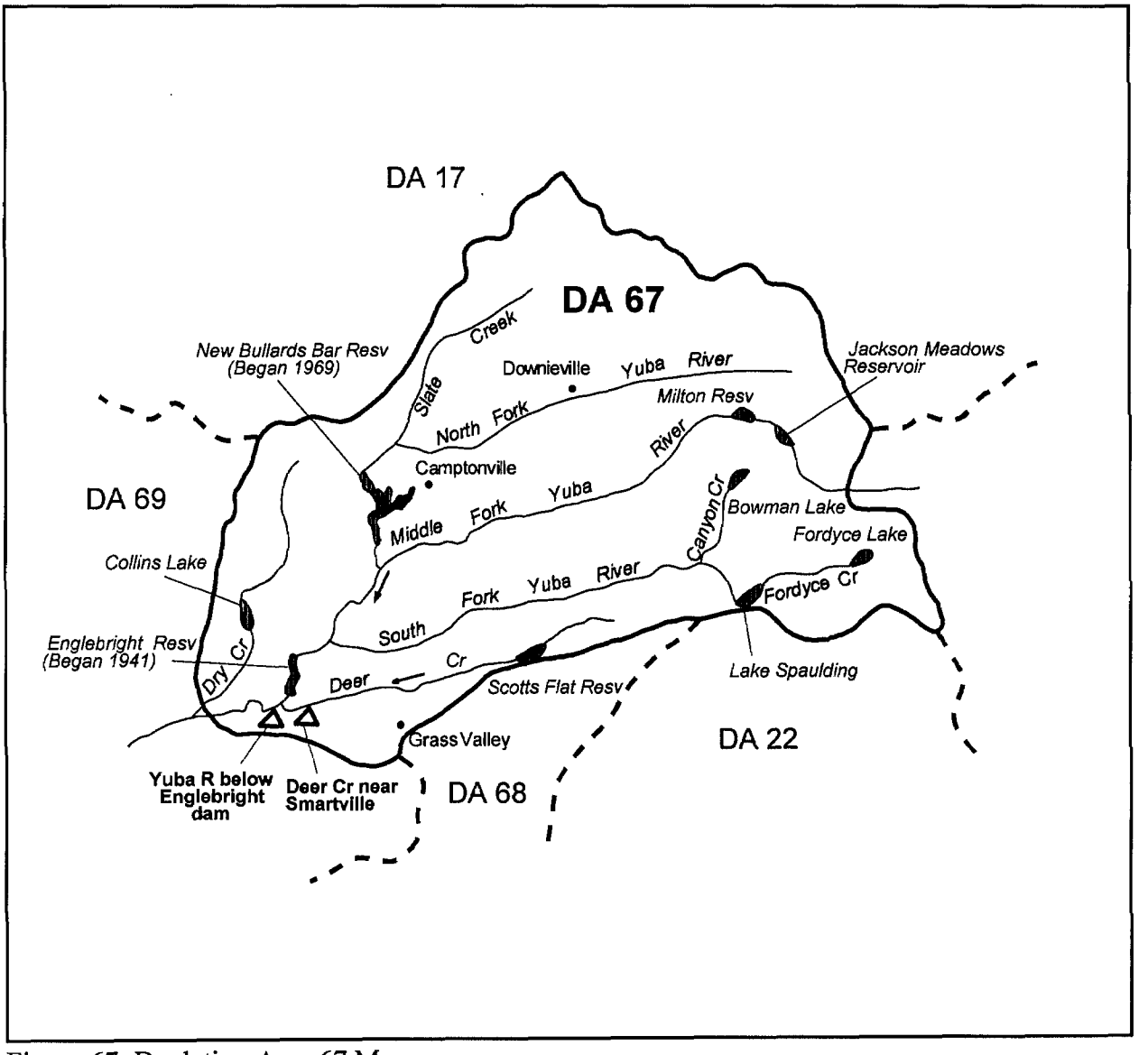


Figure 67: Depletion Area 67 Map

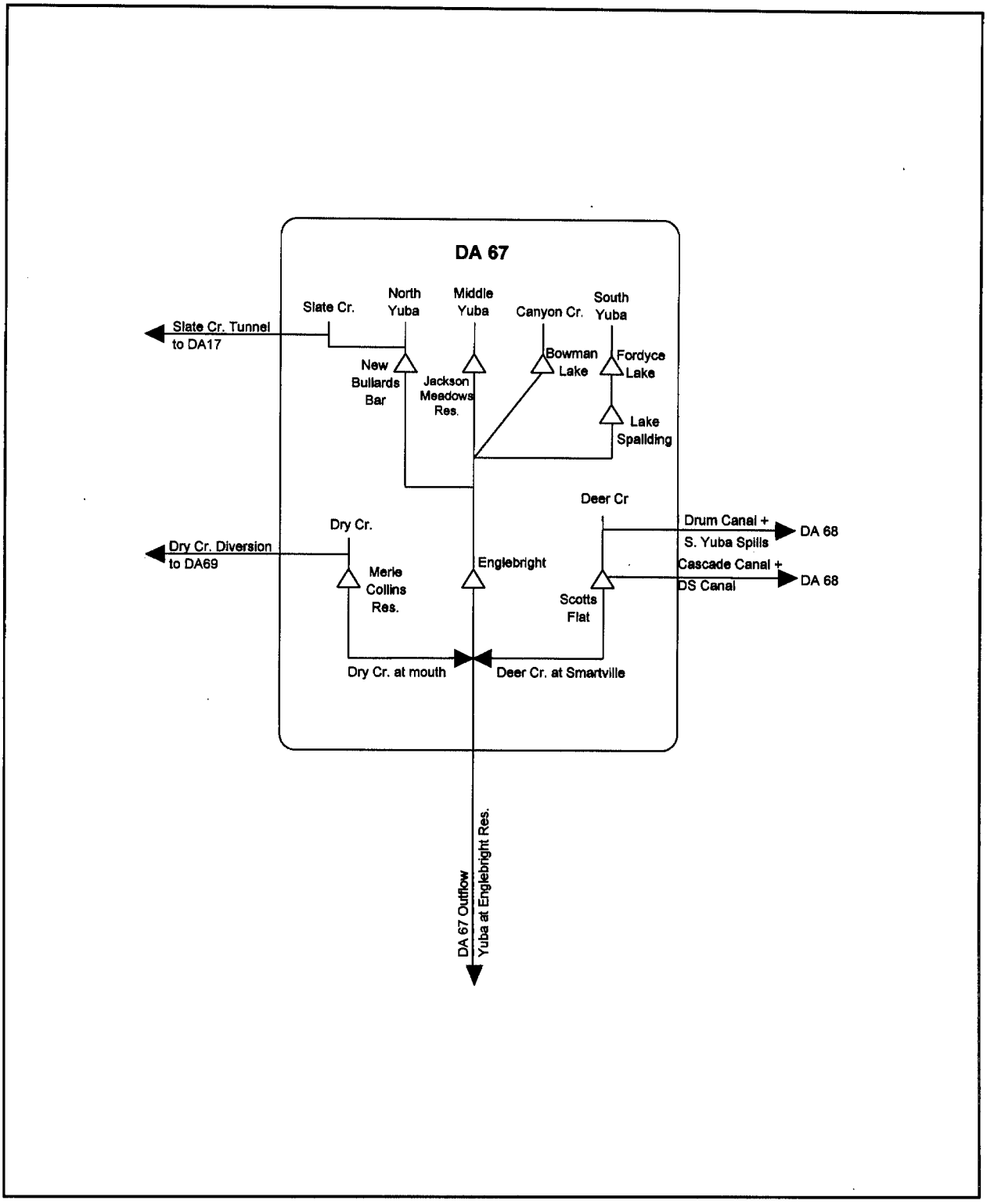


Figure 68: Depletion Area 67 Schematic

DEPLETION AREA 68
BEAR RIVER NEAR WHEATLAND

Depletion Area 68 is the drainage area for the Bear River which drains into Camp Far West Reservoir. The Bear River joins the Feather River just above Nicolaus. DA68 is located on the east side of the Central Valley just between Lake Spaulding and Camp Far East Reservoir. The Bear River is a tributary to Feather River. The outflow gage is located on Bear River near the town of Wheatland.

There are no areas upstream of this depletion area. The downstream area is DA69.

Three reservoirs are modeled in DA68. The names and capacities are listed in the table below:

Reservoir	Max. Capacity (TAF)	Completion Date
Rollins Reservoir	66.0	1965
Combie Lake	5.5	1928
Camp Far West Reservoir	103.0	1963

The following diversions transfer water out of the Bear Drainage area into other areas. These are called Exports. They include Boardman & Towle Canals, Bear River Canal, Combie Canal, and Tarr Ditch. There are additional diversions which transfer water into the Bear River Drainage area from outside areas. They include Drum Canal, South Yuba Canal Spills, Lake Valley Canal, Cascade Canal, and D-S Canal.

HEC3 MODELING: A depletion analysis is no longer performed on DA68. Instead, the Bear River Basin was modeled using a modified version of the U. S. Army Corps of Engineer's HEC3 computer program. This model allows the amount of water leaving the Bear River Basin to be calculated with different conditions imposed upon the basin.

The HEC3 model of the Bear River required 15 Control Points. Three of these were reservoir control points as described above, and one was for a possible future reservoir, Garden Bar Reservoir. All the remaining control points are for diversions or return flows. Drum Canal and South Yuba Canal spills were combined as one import as well as D-S and Cascade Canals since that was the condition they were exported from the Yuba River HEC3 model. Part of Tarr Ditch and South Yuba Canal are imports to DA67. The local natural flows are represented by inflows to Wheatland (Control Point 30) or Reservoir control points and are designated by

IN and the control point number in the model. Projected outflow to Depletion Area 69 is the flow leaving Camp Far West Reservoir (control point 4). The network diagram for the model is included in Appendix A3.

Consumptive Land Use and Fish Flows also impact the available water in the Bear River basin which can be described in details in the "Bear River Watershed Model" report.

The study period was for 59 years from 1922 to 1980. Operation studies were conducted for the Bear River with 1980, 1990, 2000, and 2010 levels of development with the same hydrologic conditions as occurred from 1922-1980.

Unimpairing the historic data of the furthest downstream gage, the Wheatland gage, was done to determine the natural flow on the Bear River. The study period was for 59 years from 1922 to 1980.

Table below summarizes how the Bear River was unimpaired, using the 59 year averages of the flows:

UNIMPAIRED WHEATLAND SUMMARY
1922-80 AVERAGES (TAF)

Impaired Flow at Wheatland Gage		294.5
Imports		
Drum Canal		287.5
South Yuba Canal Spills		17.5
Lake Valley Canal		8.1
90% Cascade Canal		24.7
85% D-S Canal		18.6
	Subtotal	-356.4
Exports		
75% Boardman & Towle Canals		14.4
Bear River Canal		244.4
Combie Canal		25.6
65% Tarr Ditch		9.9
	Subtotal	+294.3
Net Depletions		+11.5
Reservoir Evaporation		
Rollins		0.8
Combie		0.5
Camp Far West		2.4
	Subtotal	+3.7
Reservoir Storage		
Rollins		0.9
Combie		0.1
Camp Far West		1.1
	Subtotal	+2.1
Below Camp Far West Reservoir Exports		
South Sutter and CFWID		+38.1
Unimpaired Flow at Wheatland		278.8

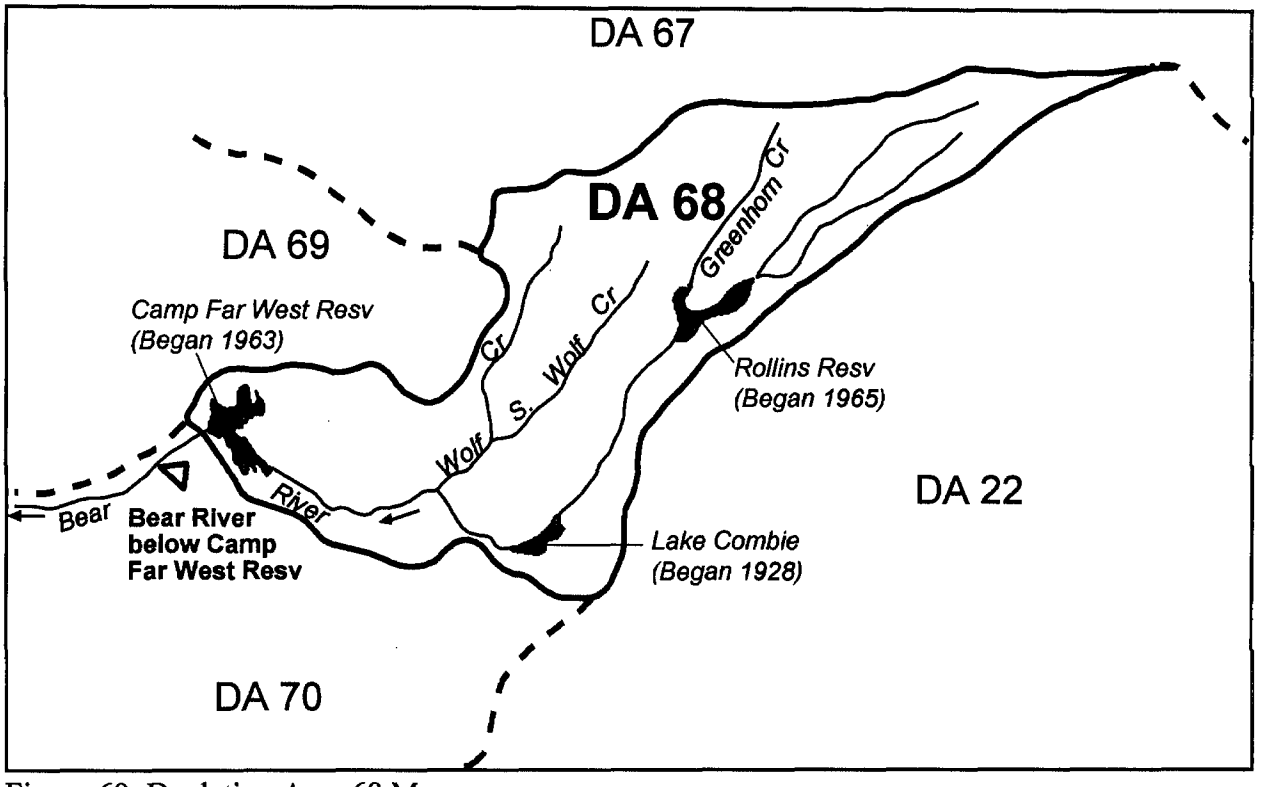


Figure 69: Depletion Area 68 Map

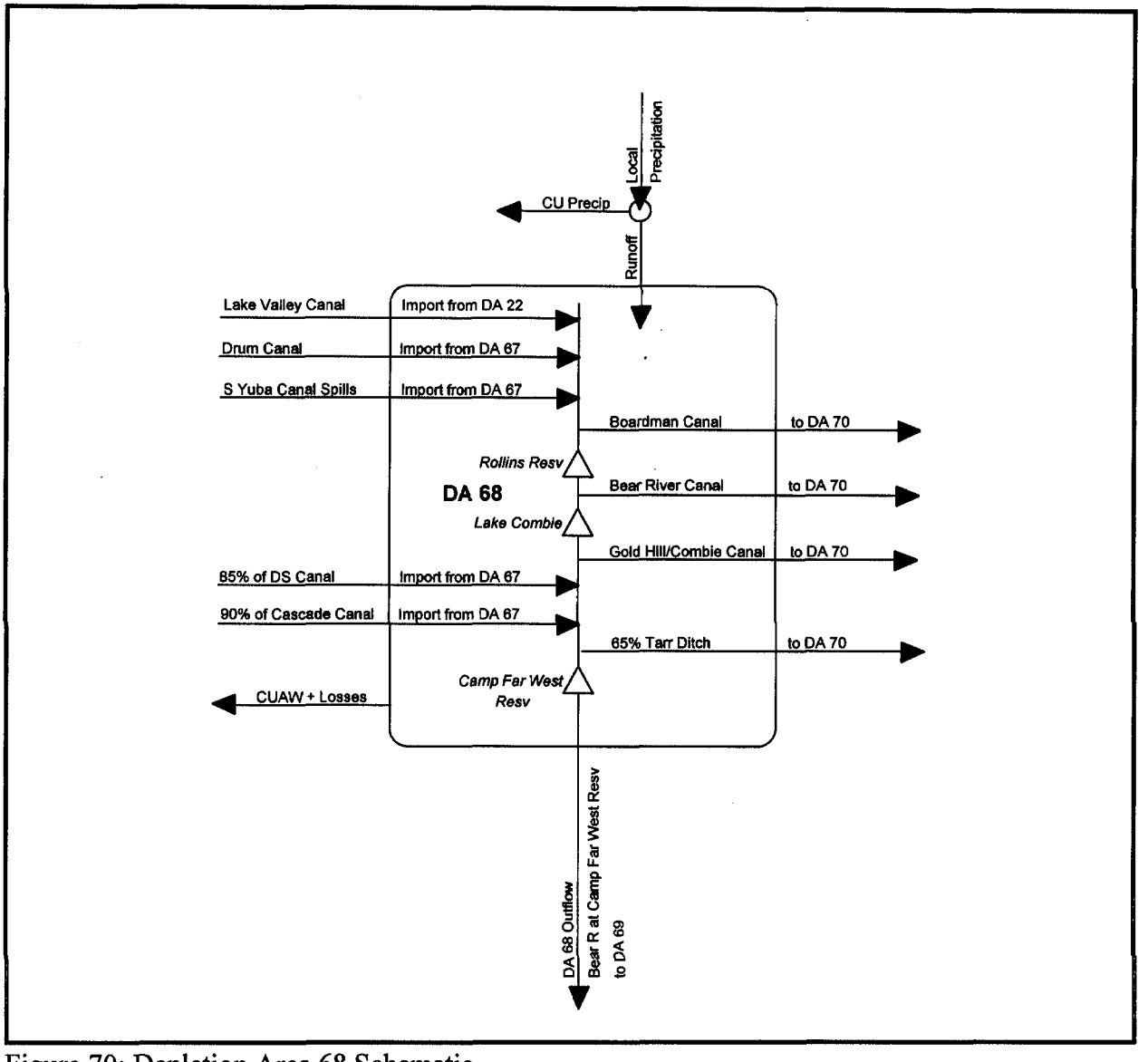


Figure 70: Depletion Area 68 Schematic

DEPLETION AREA 69
LOWER FEATHER RIVER

Depletion Area 69 covers the segment of the Feather River from Oroville to East Nicolaus. It also covers the Yuba River below Englebright Dam to its confluence with the Feather River just below Marysville. DA69 covers the cities of Chico, Oroville, Marysville, and Yuba City. The Thermalito Forebay and Afterbay and the Sutter Bypass are also located in DA69.

Exports in DA69 include the Bear River diversions to DA70 through Camp Far West Irrigation District South Canal and South Sutter Water District main conveyance canal plus left bank diversions from the mouth of the Feather River to the confluence of the Bear River. Bear River and Feather River both export to DA70.

PROJECTED OUTFLOW: The projected outflow of DA69 is calculated as:

+ Historic outflow
+ Historic export South Sutter W.D.
- Projected export South Sutter W.D.
+ Historic export Feather River left bank
+ Projected export Feather River left bank
- Increased import Forbestown Ditch
+ Increased import Miner's Ranch Canal
+ Increased import Spring Valley Ditch
+ Increased import Dry Creek Diversion
+ Increased import Tarr Ditch
+ Basin modification to remove Oroville effects
+ Basin modification to redistribute shortages
+ Upstream modification, DA17 (Projected outflow - Historic outflow at Oroville Dam site)
+ Upstream modification, DA67 (Projected outflow - Historic outflow near Smartville)
+ Upstream modification, DA68 (Projected outflow - Historic outflow below Camp Far West Dam site)
+ Historic depletion
- Projected depletion
+ Projected Additional Ground Water Pumping
- Projected Additional Ground Water Recharge
+ Project water

HISTORIC OUTFLOW: Historic outflow of DA69 is equal to the flow of the Feather River at its mouth. The outflow was estimated as the combined flows of the Sacramento River at

Verona and the Fremont Weir overflows to Yolo Bypass minus the historic outflows of Depletion Areas 12 and 15.

10/21 - 9/54 Monthly flows for the Sacramento River at Verona were taken from Table 9 of the 1957 Joint Hydrology Study report. As indicated in the footnotes of Table 9, monthly flows for water years 1922 and 1923 and November through March flows for water years 1924 through 1929 were estimated. These flows were re-estimated in November 1987, in order to obtain a better water balance between the rim station inflows and the combined outflows of the Sacramento River at Verona and Fremont Weir. The re-estimated flows are described in more detail in the documentation for DA 70.

10/54 - 9/91 Monthly flows for the Sacramento River at Verona were taken from the USGS Water Resources Data reports. Fremont Weir overflows were taken from the DWR Water Supervision reports. Beginning January 1978, Fremont Weir flows were obtained from the DWR Central District Office. Historic outflow includes RD 1500 Drain flow.

HISTORIC EXPORT: The historic export is calculated as the Bear River diversions to DA70 through Camp Far West Irrigation District South Canal and South Sutter Water District main conveyance canal plus left bank diversions from the mouth of the Feather River to the confluence of the Bear River. Both Bear and Feather River diversions export to Depletion Area 70.

Bear River diversion began March 1964. The data was obtained from Parsons and Brinckerhoff report called "Garden Bar Dam and Reservoir Hydrology Confirmation Study" dated August 1984. The data is listed in Columns 7 and 8 beginning on page 113.

Feather River left bank diversions for water years 1931, 1933-37, 1939, and 1942-69 were obtained by summing the left bank diversions below mile 12 from the DWR Water Supervision reports. Estimated years prior to 1933 were assumed to be 1 taf/month similar to 1934. Diversions for the years 1938, 1940, and 1941 were estimated to be 1 TAF/month in April and September and 2 TAF/month in May through August. Diversions for the years 1970 through 1980 were estimated to be similar to 1968.

PROJECTED EXPORT: Projected exports are South Sutter WD diversion from the Bear River and left bank diversions below mile 12 from the Feather River.

South Sutter WD diversion was estimated in DWR's 1990 Bear River HEC-3 operation study. The input diversion was estimated as ten percent less than the 2000 level Parsons,

Brinckerhoff, Quade and Douglas estimate as reported in the "Garden Bar Dam and Reservoir Hydrology Confirmation Study."

1990 level Feather River left bank diversions were assumed to be the same as historic 1970-80 estimates.

INCREASED IMPORTS: Increased imports equal the projected minus historic imports from adjacent depletion areas. There are five imports into Depletion Area 69: Forbestown Ditch from DA17, Miner's Ranch Canal from DA17, Spring Valley Ditch from DA17, Dry Creek diversion from DA67, and Tarr Ditch from DA68.

Forbestown and Miners Ranch imports are described in Depletion Area 17.

Increased import from Spring Valley ditch equals the average (1922-52) historic diversion of Spring Valley near Yankee Hill for the period October 1921 - December 1924. Beginning January 1925 the projected equals the historic import and the increased import is zero. Spring Valley ditch diverts from Concow Creek on the West Branch of the Feather River into the Miocene Canal. The diversion began January 1925.

Historic import from Dry Creek in DA67 during the irrigation season April through October equals 33% of the diversion into Tennessee Creek and Sicard Flat Ditch. The import was estimated to begin April 1964 following the completion of Merle Collins Reservoir. Historic import during the winter months was assumed to be zero. Historic diversion into Tennessee Creek and Sicard Flat Ditch for the period January 1967 through November 1977 was taken from a July 1978 study by Murray, Burns, & Kienlen called "Browns Valley Irrigation District Water Supply Analysis". Historic diversion for the period April 1964 through December 1966 and December 1977 through September 1991 was estimated by a similar year method based on Dry Creek inflow to Merle Collins Reservoir.

The projected import for Dry Creek is equal to 57% of the future demand on Merle Collins Reservoir. The future demand was also obtained from the Murray, Burns, & Kienlen report.

The projected and historic Tarr Ditch import data from DA68 are from DWR's 1990 Bear River HEC-3 operation study. Only about 55 percent of Tarr Ditch flow reaches DA69. The 1990 level Tarr Ditch was estimated as a ten percent increase of the 1970 to 1980 historic average.

BASIN MODIFICATION: Basin modifications include adjustment to remove the effects of historic Oroville Lake and Thermalito Afterbay and a short supply adjustment.

The first modification equals the historic change in storage of Lake Oroville and Thermalito Afterbay plus their evaporation as reported in the USGS Water Resources Data reports.

The second modification redistributes water in surplus supply months to short supply months.

PROJECT WATER: Project water represents storage withdrawals from Oroville Reservoir required to satisfy Feather River Service Area (FRSA) and Palermo Canal diversion requirements. Surface water supply for FRSA include Oroville inflow, Kelly Ridge return to the Feather River, and Oroville project water. Surface water supply for Palermo Canal include Oroville inflow and project water.

Projected FRSA diversion requirement was developed from data taken from Jan Rogers' May 26, 1983 memo. A correction to Sunset Pumps from 57 to 65 TAF/year was made according to Mullnix' June 17, 1983 memo. In order to develop monthly diversion requirement and deficiency values, Table 1 of Jan Rogers' memo was recombined as follows:

	Normal Year	25% Deficient Year	50% Deficient Year
Districts	555	417	280
Additional Drought Allowance	0	35	35
Carriage Water	5	5	5
Sunset Pumps	65	42	29
PG&E	295	257	220
FRSA Agriculture	920	756	569
Beneficial Use & Duck Clubs	27	37	80
M & I (1980)	8	8	8
Additional (1990)	25	25	25
M & I Total	33	33	33
FRSA Total	980	826	682

Deficiencies of 25% were taken on FRSA agriculture and Beneficial Use in the critical following critical years of 1934 and 1977. Monthly pattern for FRSA agriculture is the same as DA69 projected diversion requirement.

Projected diversion for Palermo Canal at a 1990 level is estimated to be 8 TAF/year. The projected amounts are based on the historic average (1970- 85) Palermo Canal diversion.

GROUND WATER PUMPING: Historic annual GWP for 1961-1977 was developed by USGS. The projected and historic GWP for 1922-1960 and 1978-1991 was estimated using the following equation:

GWP = .48(diversion req.) - .0289(Apr.-Sept. DA12 historic outflow) - 22
Diversion req. = (DA69 cuaw)/e

The cuaw was computed in the consumptive use model as the sum of the consumptive use of applied water of the irrigated crops. Urban cuaw was excluded.

e = efficiency factors for DA69. DA69 efficiency factors vary from .30 to following critical years (1934 and 1977).

GROUND WATER RECHARGE: Ground water recharge is based on a simulation model developed by Boyle Engineering. Projected ground water recharge is not yet available to be incorporated into the depletion analysis.

NO STATE WATER PROJECT OUTFLOW: A second depletion study was run in which the effects of the DWR Feather River projects were removed. Project water was excluded. Modification was included to remove the effects of Davis, Antelope, and Frenchman Lakes. Efficiency factors were revised to reflect pre-Oroville return flow. Additional shortages were assumed to be met from increased ground water pumping.

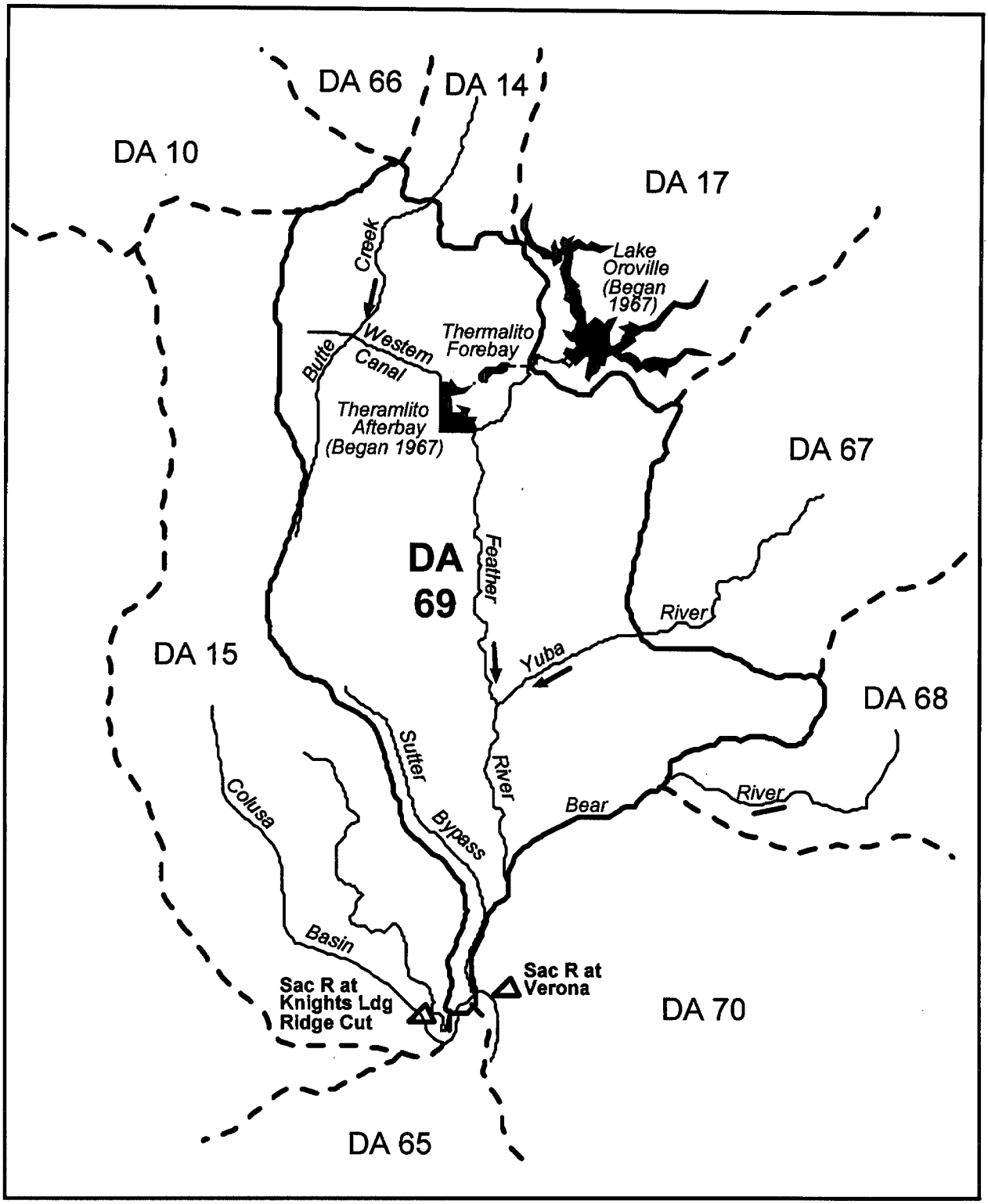


Figure 71: Depletion Area 69 Map

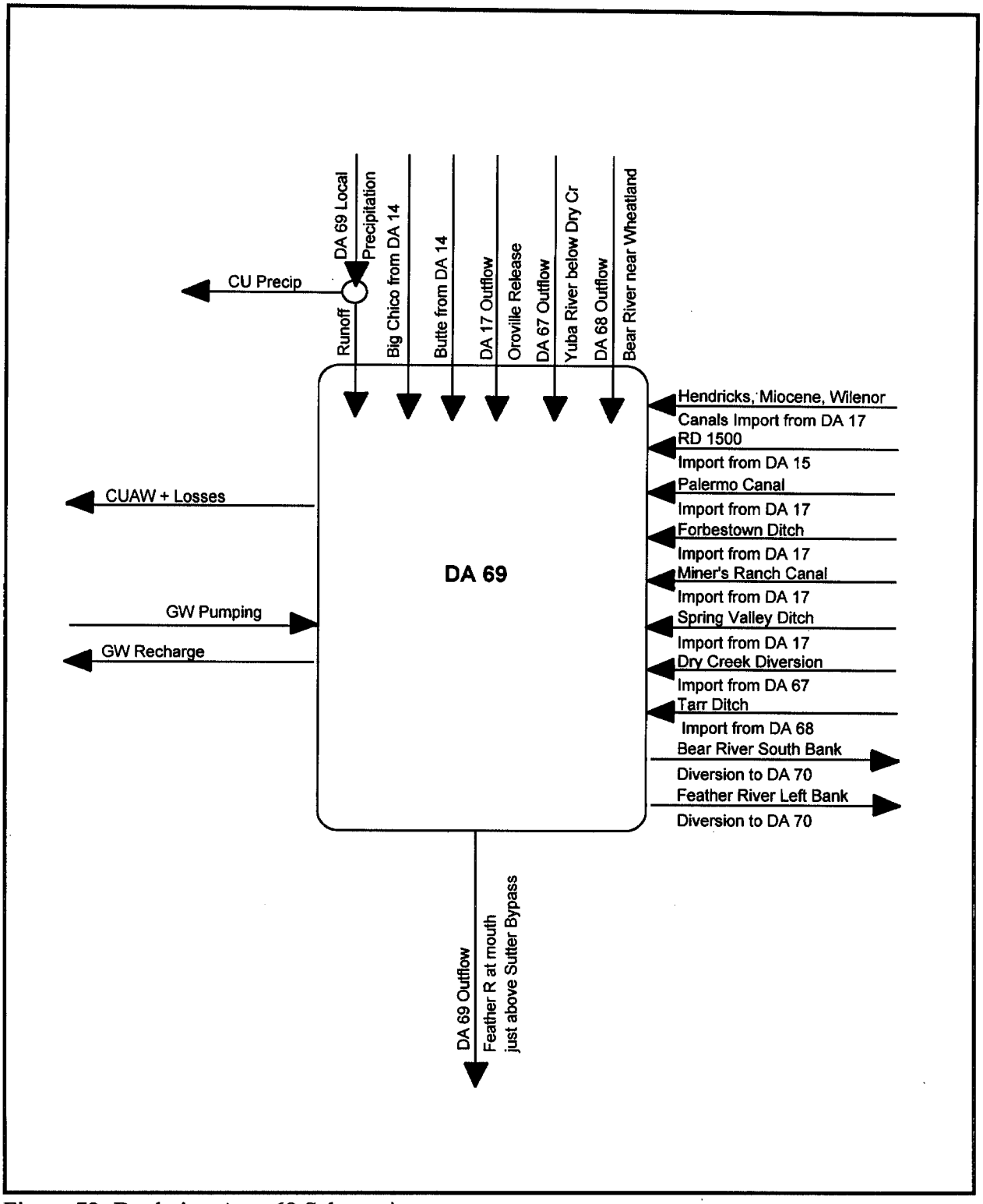


Figure 72: Depletion Area 69 Schematic

DEPLETION AREA 70
SACRAMENTO RIVER AT SACRAMENTO

Depletion Area 70 covers the Sacramento Valley floor segment of the Sacramento River from Verona to Sacramento. It also covers the segment of the American River from Folsom Lake to its confluence with the Sacramento River at Sacramento. Lake Natoma located on the American River is located in DA70. DA70 covers most of the Northern Sacramento area.

Exports from DA70 include the South Canal Spill to Folsom Reservoir and Sacramento River right bank diversions in Yolo Bypass.

PROJECTED OUTFLOW: The projected outflow of Depletion Area 70 is calcualted as:

+ Historic Outflow
+ Historic Export South Canal Spills to Folsom Reservoir
- Projected Export South Canal Spills to Folsom Reservoir
+ Historic Export Sacramento Right Bank Diversions
- Projected Export Sacramento Right Bank Diversions
+ Historic Export City of Sacramento from Sacramento and American Rivers
- Projected Export City of Sacramento from Sacramento and American Rivers
+ Increased Import Combie Canal
+ Increased Import South Sutter Water District
+ Increased Import Bear River Canal
+ Increased Import Boardman Canal
+ Increased Import Placer County Water Agency
+ Basin Modification to Remove Effects of Historic Folsom Reservoir
+ Basin Modification to Remove Effects of Historic Folsom South Canal
+ Upstream Area Modification DA12
+ Upstream Area Modification DA15
+ Upstream Area Modification DA22
+ Upstream Area Modification DA69
+ Historic Depletion
- Projected Depletion
+ Additional ground water pumping at Projected level
- Additional ground water recharge at Projected level

HISTORIC OUTFLOW: The historic outflow of Depletion Area 70 is calculated as the combined flow of the Sacramento River at Sacramento and the Sacramento Weir Spills to Yolo Bypass. For the period October 1921 through September 1954 monthly flows for the Sacramento River at Sacramento were taken from Table 10 of the 1957 Joint Hydrology Study.

Monthly flows for the Sacramento Weir were taken from Table 52.

As indicated in Table 10 the 1957 Joint Hydrology Study monthly flows for water years 1922 and 1923 and the November through March flows for water years 1924 through 1939 were estimated as the Sacramento River at Verona adjusted for accretions and diversions between Sacramento and Verona. Prior to 1930 monthly flows of the Sacramento River at Verona were estimated by correlation with the rim station inflow above Verona. The estimated Verona flows when combined with Fremont Weir spills, in several months, failed to account for the combined inflow of the Sacramento River above Red Bluff, the Feather River, the Yuba and the Bear rivers.

The Sacramento River at Verona and Sacramento were re-estimated November 1987 by correlating the Verona and Fremont Weir spills to the combined flows of the Sacramento River at Red Bluff, the Feather at Oroville, the Yuba at Smartville, and the Bear River at Wheatland.

Beginning in water year 1955, monthly flows for Sacramento River at Sacramento and Sacramento Weir spills to Yolo Bypass were taken from USGS Water Resources Data reports.

Beginning October 1979, the Sacramento River gage was relocated downstream and renamed "Sacramento River at Freeport".

HISTORIC EXPORT: Historic exports in DA70 are South Canal Spill to Folsom Reservoir and Sacramento River right bank diversions in Yolo Bypass.

The historic South Canal export for the period Ocotber 1921 through September 1929 was taken from a DWR compilation sheet labeled "Input from Wise Power Plant to American River (South Canal)". The indicated source of record is "American River Water Supervision computation 1930". The source of data is not known for the period October 1929 through September 1931. The historic export for the period Ocotber 1931 through September 1978 was taken from a DWR tabulation called "South Canal below Tunnel 14, Index No. A6D090". The historic export for the period October 1978 through September 1980 was taken from DWR Snow Surveys computation sheets. It is called "Bear River Canal (South Canal) YB90". Snow Surveys uses the data to unimpaired American River inflow to Folsom Reservoir. The data is assumed to be South Canal, rather than Bear River Canal.

The historic export of the Sacramento River right bank diversions are located along the Sacramento River between Sacramento and mile 19.6. Historic exports for the period October 1921 through September 1923 were estimated as similar to water year 1925. Historic exports for the period October 1924 through September 1972 was taken from DWR Water Supervision reports. Historic exports for the period October 1972 through September 1975 equal Sacramento right bank diversions reported in DWR Water Supervision reports plus unreported

diversions estimated to be 11 TAF/year. Unreported estimates are equal to the 1961 through 1964 average. Historic exports for the period October 1975 through October 1977 were taken from USBR Monthly Reports of Operations. The exports equal diversions by Deseret Farms, Hanks, Hershey, Latter Day Saints, and Woodland Farms plus an estimated 11 TAF/year for unreported diversions. Historic exports for the period November 1977 through October 1978 were developed by USBR from Contract delivery data. Historic exports for the period November 1978 through September 1991equal diversions taken from USBR Reports of Operations plus unreported diversions estimated to be 33% of the reported diversions. The 33% was determined from the detailed 1978 data developed by USBR.

Historic export for the city of Sacramento to DA59 includes the city's diversion from the Sacramento River for the full period, 1922-80, and the city's diversion from the American River for the period March 1964-1991. The Sacramento River diversions for the non-winter months of 1924-57 and the water years 1958-69 were taken from DWR Water Supervision Reports. Winter months for 1922-57 were estimated to be 1.5 TAF/month as indicated by some of the earlier spring months. 1922-23 was estimated to be the same as 1926. American River diversions for the period 1964-69 were also taken from the DWR Water Supervision Reports. For the period 1970-91 both Sacramento and American River diversions were taken from the City's Water Dept. Summaries of pumpage and power used at each plant.

PROJECTED EXPORT: Projected export for DA70 include South Canal spills to Folsom Reservoir and Sacramento River right bank diversions.

Projected export by South Canal is based on information developed by PG&E in its application to the Federal Energy Regulatory Commission for an amendment to its existing license. The amendment would allow PG&E to build a power plant at their point of discharge into Folsom Lake. The plant is referred to as the Newcastle Powerhouse. The application was filed in July, 1981. Exhibit B, page 1, states:

> (I) The minimum, mean and maximum flows at Newcastle Powerhouse are estimated from theoretical studies. Based on these studies canal flows range from 0 cfs in August of dry years to about 395 cfs maximum in low irrigation months with an overall average of 194 cfs.

Based on this sketchy information, a table of projected Newcastle releases was created that matches the average flow of 194 cfs (140,400 acre-feet per year). The projected export for individual years varies according to a wetness curve relating annual historic South Canal spills to the natural flow of the Yuba River. The monthly pattern was made similar to the historic South Canal spills of 1966 through 1980.

Projected export of the Sacramento right bank diversions equals the amount of water, in

addition to projected Knights Landing Ridge Cut, that would be needed to fully meet projected diversion requirements in the Yolo Bypass service area. The Yolo Bypass service area are those lands irrigated by import from the Sacramento River and from DA12 import through Knights Landing Ridge Cut. Diversion requirement equals consumptive use of applied water divided by DA65 efficiency factors. The consumptive use of applied water is determined by the Consumptive Use program.

Depletion studies made after May 1990 will include export for the City of Sacramento's diversions from the American and Sacramento Rivers. The downtown portion of Sacramento and south Sacramento are actually located in DA59. In past studies this urban area, known as 'DA53 Urban', was removed from DA59 land use and added to DA70 (DA21) land use. Because the Conjunctive Use ground water model needs to be more precise in its location of land use, we have decided the keep city of Sacramento's urban area in DA59. As a result, we will be required to export the city of Sacramento's surface supply from DA70 into DA59. It should also be noted the historic depletion and projected diversion requirement for DA70 will be drastically changed as a result of the changed land use.

Projected export for the city of Sacramento is estimated to be 40 TAF/yr from the American River and 40 TAF/yr from the Sacramento River. The projection is based on the level of historic diversions made from each river in the late 1970's, early 1980's. In certain months on 1977 the flow of the American River became critical and the City of Sacramento temporarily stopped diverting from the American River and increased their diversion on the Sacramento River. For a projected export a similar shift in diversion was made for both 1977 and 1934. Also, a 20% deficiency was taken for the March-Feb. periods of 1934 and 1977.

GROUND WATER PUMPING AND RECHARGE: Ground water pumping and recharge, historic and projected, are to be updated when the Conjunctive Use GW/SW model is completed. As of this date, 6/90, the only ground water pumping and recharge data available is from the ground water model computed by Boyle Engineering, March 1989. Only historic and projected pumping and historic recharge data was used. Therefore, the ground water modification currently in this depletion study is equal to historic GW recharge - historic GW pumping + projected GW pumping.

Annual ground water pumping was computed by Boyle Engineering using the following multiple regression equation:

Annual DA70 GWP = 0.49 (Prime Diversion Supply)
- .0019 (DA70 April-Sept. Historic Outflow)
+ 7.89

Both agricultural and M & I are included in the ground water pumping.

Monthly distribution was made using the CU of Applied for Irrigated and Urban + Domestic Urban Water use as developed by the DWR Consumptive Use Program.

IMPORTS: Imports into DA70 include Combie Canal, South Sutter Water District's Southline and Conveyance Canals, Bear River Canal, Boardman Canal, and American River diversion to Placer County Water Agency. Bear River Canal and Boardman are described under DA68. South Sutter Water District export is described under DA69. American River diversion to PCWA is described under DA22.

BASIN MODIFICATION: Basin modifications in DA70 include a modification to remove the effects of historic Folsom reservoir, Natomas reservoir, and Folsom South Canal.

Modification to remove the effects of Folsom Reservoir equals the change in storage and evaporation of Folsom and Natomas Reservoirs. End of month storage and evaporation of Folsom and Natomas Reservoirs are from USBR Monthly Reports of Operations.

Modification to remove effects of Folsom South Canal equals the historic diversion of Folsom South Canal into Depletion Area 59. Diversion of Folsom South Canal was taken from USBR Monthly Reports of Operations.

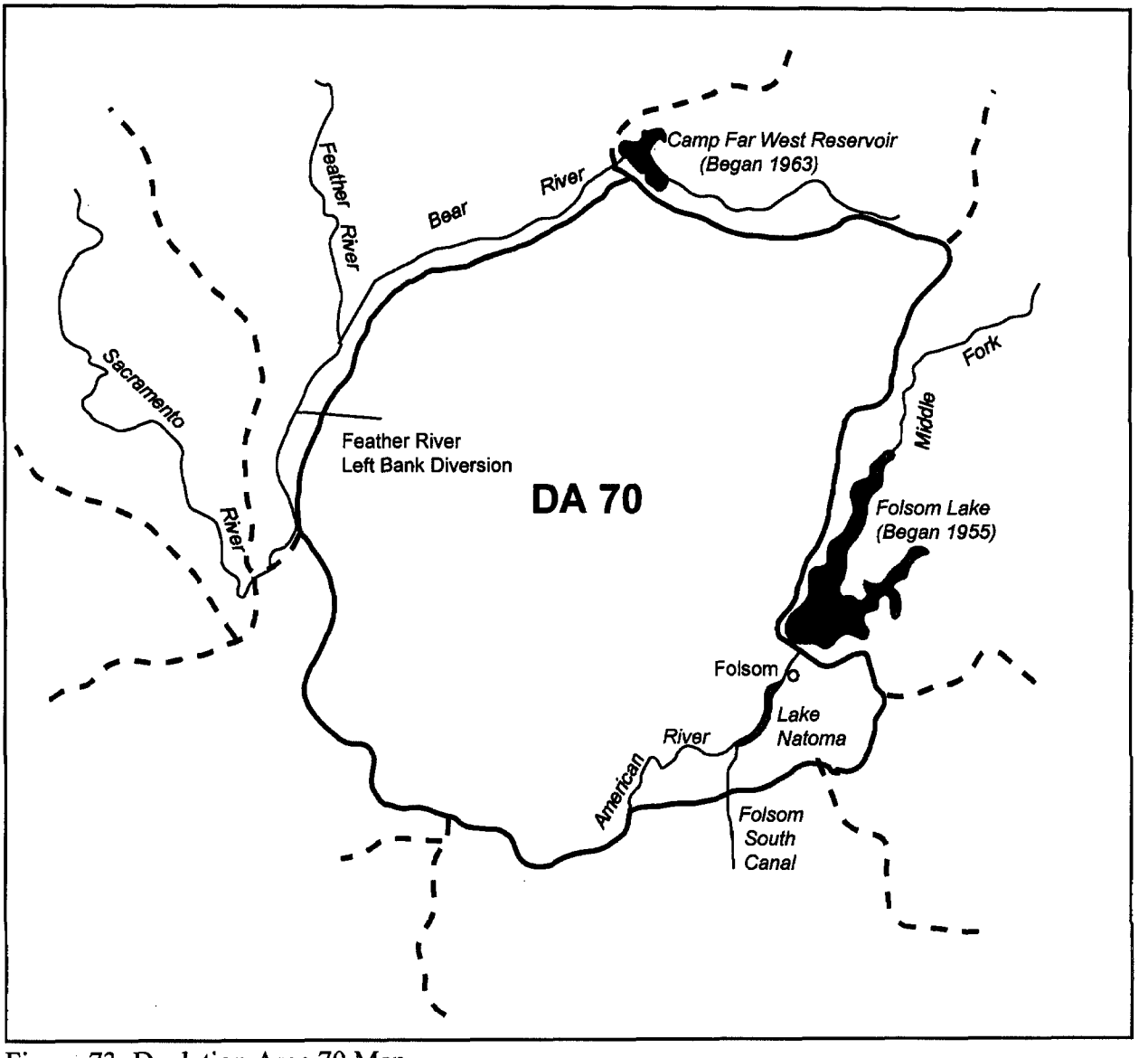


Figure 73: Depletion Area 70 Map

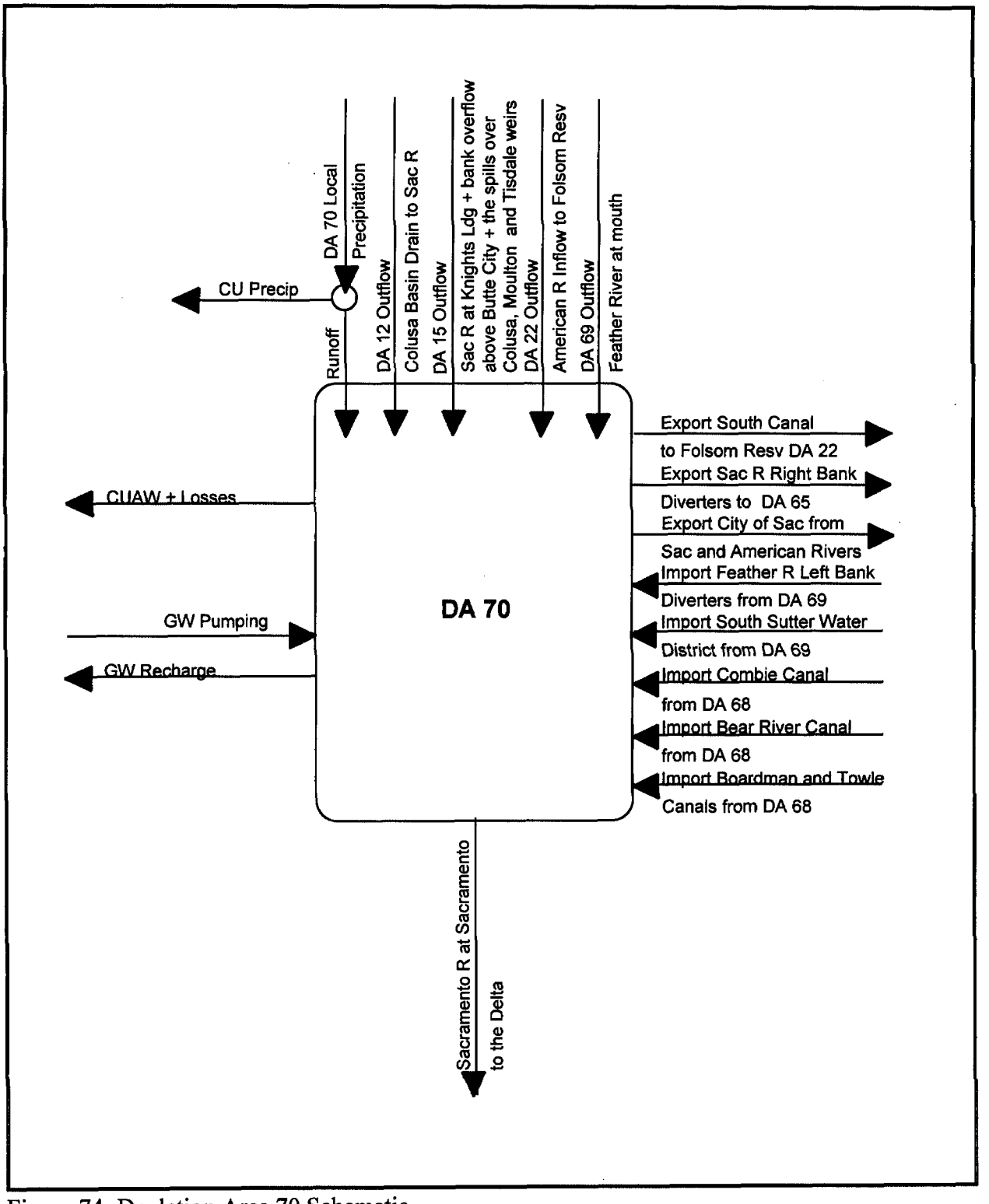


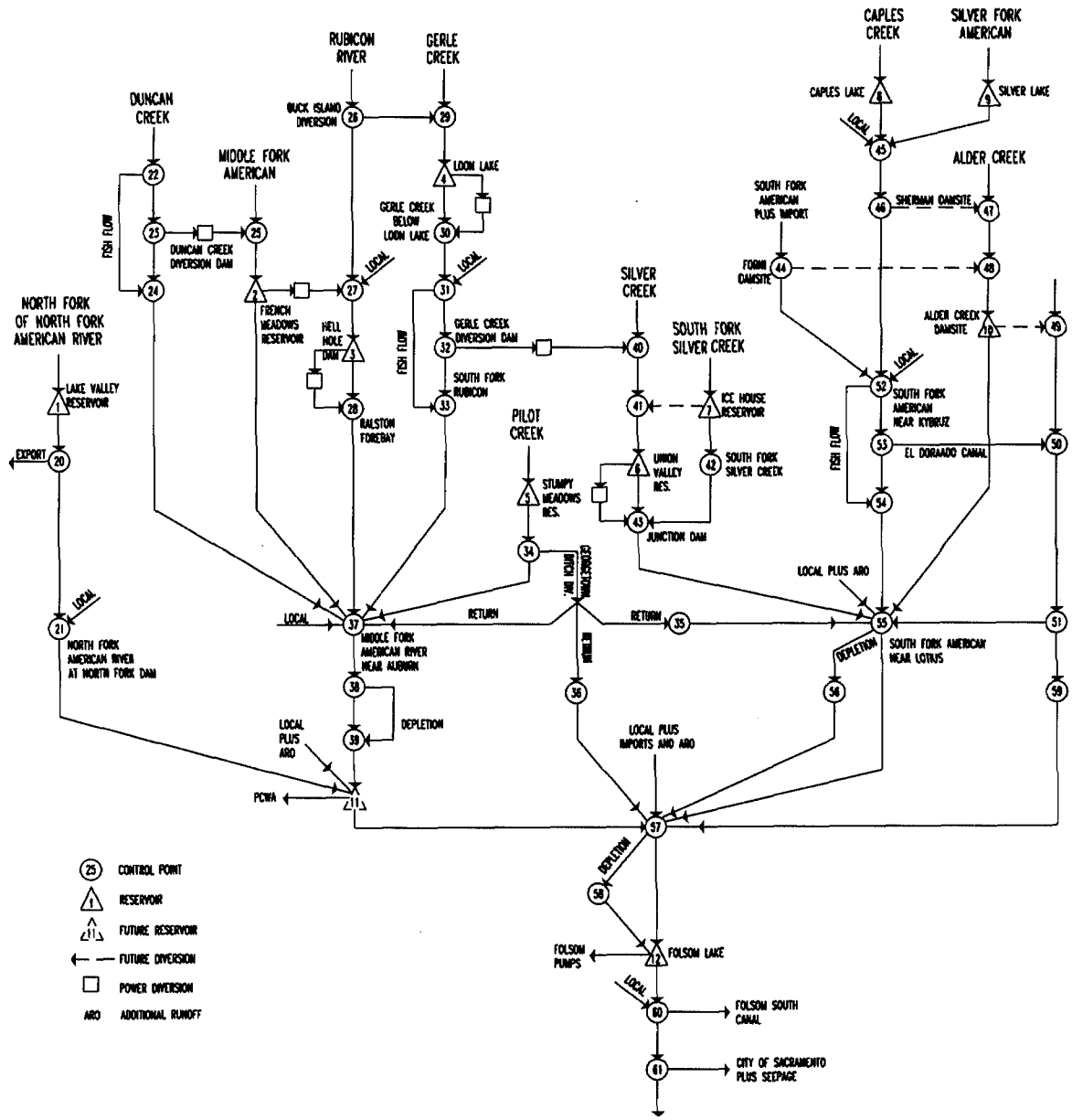
Figure 74: Depletion Area 70 Schematic

APPENDIX A

Appendix A1

UPPER AMERICAN RIVER MODEL NETWORK

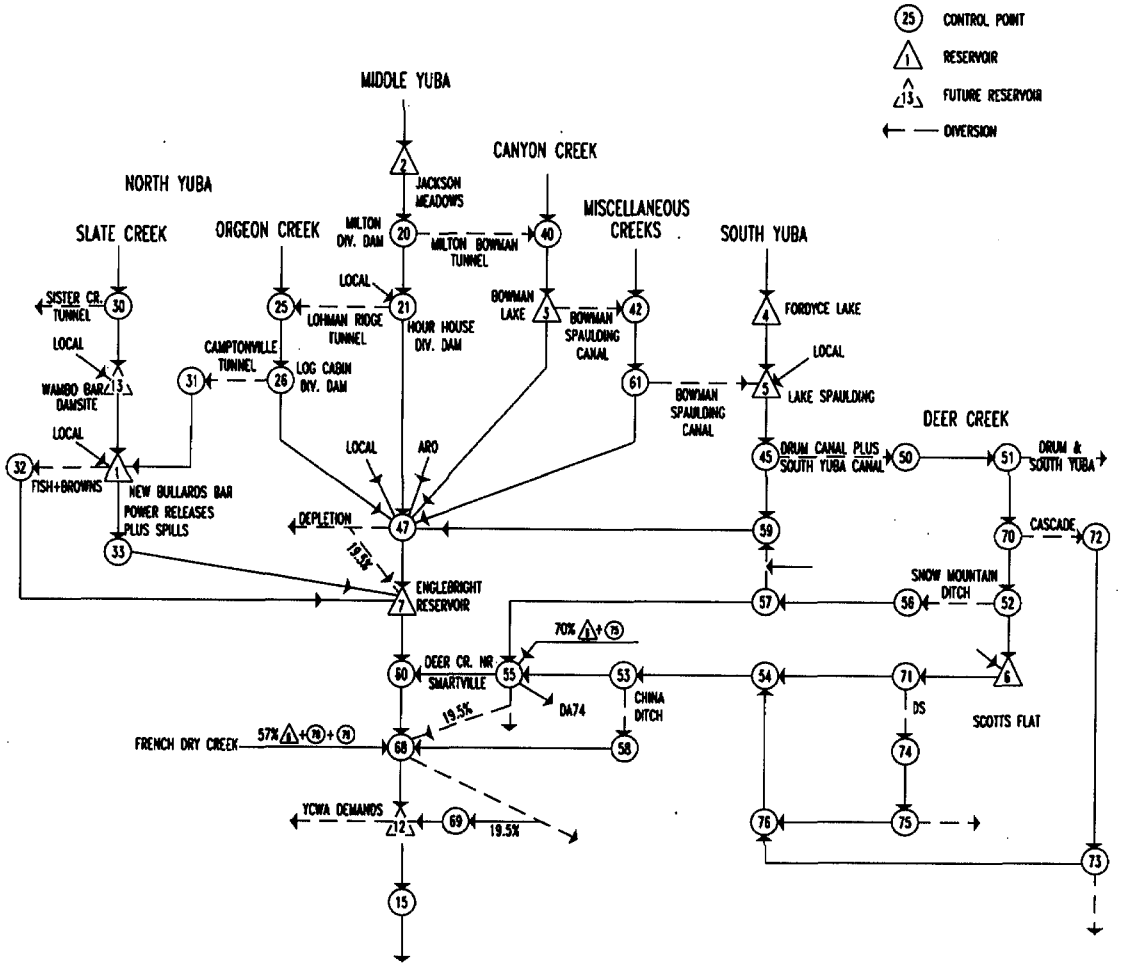
Revised on 12/12/94



Appendix A2

YUBA RIVER MODEL NETWORK

Revised on 12/27/94



Appendix A3

BEAR RIVER MODEL NETWORK

Revised on 12/27/94